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WADC-TR-59-602 PART II

INVESTIGATION OF MATERIALS CAPABILITIES OF MATERIAL SYSTEMS IN SOLID ROCKET MOTORS

PART II. ANALYSIS OF HEAT TRANSFER FACTORS

TECHNICAL REPORT No. WADC-TR-59-602, PART II

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DIRECTORATE OF MATERIALS AND PROCESSES AERONAUTICAL SYSTEMS DIVISION AIR FORCE SYSTEMS COMMAND WRIGHT-PATTERSON AIR FORCE BASE, OHIO

PROJECT No. 7350, TASK No. 73500

(Prepared under Contract No. AF 33(616)-7365 by Aerojet-General Corporation, Sacramento, California; E. M. Sadownick, Author)

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FOREWORD

This report was prepared by the Aerophysics Department of Aerojet-General Corporation, Sacramento, California, under Contract No. AF 33(616)-7365. The contract was initiated under Project No. 7350, "Refractory Inorganic Non-Metallic Materials," Task No. 73500, "Ceramic and Cermet Materials Development." The work was administered under the direction of the Directorate of Materials and Processes, Deputy for Technology, Aeronautical Systems Division, with Lt. T. E. Lippart acting as project engineer.

The work was conducted between 15 June 1960 and 15 May 1961, supervised by G. Kraus through March 1961 and by S. E. Colucci from April 1961 to May 1961.

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ABSTRACT

Temperature histories of various nozzle materials systems were analyzed parametrically, and a series of hot-flow tests were conducted in support of the analytical study. The analysis showed that chamber pressure and gas temperature affect duration capability significantly, but throat diameter does not. Thermophysical properties of the flame barrier and heat sink also affect duration, but, by comperison, the effect of variations of thermophysical properties of the insulator and load-bearing member is relatively small. High product of density and heat capacity, and moderately high thermal conductivity, are desirable for the flame barrier and heat sink. The heat transfer analysis indicated that significant increases in nozzle duration capability are possible when properly oriented anisotropic material is used. Tests of six nozzles with varying tungsten flame barrier thicknesses showed fairly good agreement between calculated temperatures and measured data when no aluminum oxide was deposited on the walls. When deposition occurred. the measured temperatures were lower than those calculated; but the temperatures could be brought close to agreement by considering the thermal blocking effect of the deposit.

PUBLICATION REVIEW

This report has been reviewed and is approved.

FOR THE COMMANDER:

W. G. RAMKE

Chief, Ceremics and Graphite Branch Metals and Ceremics Laboratory Directorate of Materials and Processes

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LIST OF SYMBOLS

| a | inner radius |
|----------------|------------------------------|
| ь | outer radius |
| В | Biot modulus |
| c _p | specific heat |
| D _T | throat diameter |
| F | Fourier modulus |
| h | heat transfer coefficient |
| k | thermal conductivity |
| P _c | chamber pressure |
| R | radius ratio |
| т _g | gas temperature |
| T _o | initial material temperature |
| ρ | density |
| θ | time |

I. INTRODUCTION

The trend in chemical rocket propulsion is toward the development of propellant with higher combustion temperatures. As propellant gas temperatures reach and exceed the melting points of most known materials, the problem of what nozzle materials to use becomes more difficult to solve. As a prelude to the development of nozzle-materials systems for use in future high-performance solid rocket motors, this theoretical and experimental investigation was undertaken. The effects of nozzle design and materials variables on system duration capability were described to indicate the most promising areas for subsequent materials research and development.

Many complicated factors enter into a proper understanding of nozzle materials behavior, but the role played by heat transfer is basic to all. The investigation was accomplished primarily through an analytical parametric study of the temperature histories of various nozzle systems. A series of nozzle test firings was made in support of the analytical work. Other areas of interest, such as thermal stress and erosion characteristics, were not considered here.

As materials for use at high temperatures are developed, the question arises of how accurately one needs to know the thermophysical properties to design a nozzle materials system. Consequently, the effects of errors or uncertainties in thermophysical properties were also studied, and their relative importance was determined.

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II. ANALYTICAL STUDIES

A. PROCEDURE

The current study was conducted with both three-material and four-material model systems. The three-materials system consists of a high-temperature flame barrier, an insulator, and a load-bearing member. The four-materials system consists of a high-temperature flame barrier, a high-temperature heat sink, an insulator, and a load-bearing member.

The design variables investigated were the following:

- 1. Chamber pressure
- 2. Gas temperature
- 3. Throat diameter
- 4. Radius of curvature of the throat
- 5. Material thickness

The material variables investigated were the following:

- 1. Thermal conductivity
- 2. Product of density and heat capacity
- 3. Maximum allowable material temperature

Table 1 is a list of some materials that have been used, are currently being developed for use, or are suggested by this study for use in nozzles. They are grouped by distinguishing characteristics and their function in a three-or four-materials system. The range of thermophysical properties of these materials is compiled in Table 2.

In determining the effects of the design and materials variables, the following procedure was used. Material thicknesses were arbitrarily chosen and put into a digital computer (either the IBM 704 or IBM 7090 were used) along with

II, A, Procedure (cont.)

other design data and material properties. This was basically a parametric study; constant material properties were chosen that were representative of values for actual materials. The analysis assumed one-dimensional heat transfer to a hollow cylinder; in some cases, however, two-dimensional, axisymmetric heat-transfer calculations were made. The values used for the convective coefficients of heat transfer to the nozzle wall were typical of aluminized polyurethane propellants, assuming no particle deposition (see Appendix I). The computer outputs, which were temperature histories, were then evaluated to determine the effects of the variables of interest. The computer program and the outputs are discussed more fully in Appendix II.

A single three-materials system and a basic set of design conditions were chosen as references. The reference system was tungsten-asbestos phenolic-steel. The basic design conditions were 1000 psi chamber pressure, 7000°F gas temperature, 4-in. throat diameter, and a throat radius of curvature-to-throat radius ratio of infinity (the case for a hollow cylinder). Representative material properties used for the reference system are listed in Table III.

Design conditions and material properties were varied in turn.

The four-materials system was studied by introducing heat sinks with various properties and evaluating the effect on temperature distribution and duration.

In most cases, conditions were investigated only at the throat. However, the methods used can be extended to other parts of the nozzle by selecting the appropriate combination of chamber pressure and throat diameter.

II, Analytical Studies (cont.)

B. THREE-MATERIALS SYSTEMS

1. Effect of Design Variables on Duration Capability

a. Optimum Duration

Nozzle material thicknesses may be represented by nozzle weights per unit length. The minimum weight of a particular nozzle materials system, for a specific set of design conditions, is obtained when the material thicknesses are minimum and the maximum allowable temperature of any of the materials is not exceeded. For a particular chamber pressure, gas temperature, throat diameter, and materials system, there is a minimum nozzle weight for each duration.

Nozzle weight per unit length at the throat section is plotted as a function of duration in Figure 1 for the reference system, tungstenasbestos phenolic-steel, and for design conditions of 1000 psi, 7000°F, and 4.0-in. throat diameter. The flame barrier and insulator thicknesses were minimized at each duration and the steel thickness was kept constant at 0.25 in. This thickness of steel does not absorb any significant amount of heat and could have been neglected in the heat transfer calculation. Small changes in insulator thickness will have a great effect on steel temperature, but a negligible effect upon weight. For example, the following sets of thicknesses result in weights per unit length and surface and interface temperatures at the end of 120 sec:

| | Tungsten | Asbestos Phenolic | Steel | Tungsten | Asbestos Phenolic | Steel |
|-------------------|----------|----------------------|-------|----------|----------------------|-------|
| Thickness, in. | 3.350 | 0.250 | 0.250 | 3.350 | 0.200 | 0.250 |
| Temperature, °F | 6109 | 3010 | 376 | 6109 | 3020 | 1271 |
| Wt/length, lb/in. | | 55.46 | | | 55.33 | |

A 0.050-in. change in insulation thickness results in a 900°F change in steel temperature, but a difference of only 0.13 lb/in. in throat weight per unit length. For this reason, it was considered sufficient to have the steel within a few hundred degrees of its allowable temperature when calculating minimum nozzle weight.

The initial weight increase shown on the curve of Figure 1 is nearly proportional to the duration increase. Then, the slope of the curve changes abruptly and small additional increases in duration are accompanied by very large increases in throat weight per unit length. At short duration, the maximum allowable temperature is reached only in the insulator and load-bearing members, but not in the flame barrier. At higher durations, on the steep portion of the curve, the flame barrier and load-bearing members reach their limiting temperatures, but the insulator does not.

At the point where the slope of the curve changes abruptly, and only at this point, the maximum allowable temperature is reached simultaneously in all three materials. If we consider that maximum use is made of a nozzle material when it is heated to the highest temperature it can withstand under the given conditions, then only at this point is maximum use made of each material in the system. For this reason, the point is called an optimum point, and the duration at which it occurs is called an optimum duration. For the three-materials system, the optimum duration is a practical indication of duration capability because, once reached, nozzle duration can be extended only a short time by increasing the material thickness. Soon a point will be reached at which no further increases in duration are possible, unless some of the design conditions are changed.

Figure 2 shows the effect of chamber pressure on the position and shape of curve shown in Figure 1 for throat weight per unit length vs duration. Decreasing the chamber pressure results in an increase in optimum duration. At chamber pressures of 600 psi and below, the optimum

duration is so great (beyond 350 sec) that it is not shown on the curve. Although such high durations are beyond any contemplated for the forseeable future, they are valid as a measure of the relative effect of chamber pressure.

Figures 3 and 4 show the effects of gas temperature and throat diameter, respectively, on minimum nozzle weight. An increase in gas temperature results in a decrease in optimum duration. An increase in throat diameter results first in a decrease then a small increase in optimum duration. This effect of increasing throat diameter is the result of the balancing of two effects: (1) the increased heat transfer to the wall due to the geometry change (increased ratio of inner-to-outer diameter), and (2) the decreased heat transfer to the wall due to a decrease in the convective heat transfer coefficient (resulting directly from the increased diameter). At higher diameters, the curve changes a slope a short distance above the indicated optimum point.

The relationship between the design conditions and optimum duration is shown more clearly in Figure 5. Here, optimum duration is plotted as a function of chamber pressure, gas temperature, and throat diameter. Each curve was obtained by cross-plotting the optimum points shown in Figure 2 through 4 as a function of the design variable. Small increases in chamber pressure or gas temperature result in very large decreases in optimum duration, but, by comparison, a change in throat diameter affects optimum duration very little.

Increases in optimum duration that result from decreases in chamber pressure or gas temperature always result in nozzle weight increases. This is because a decrease in pressure or temperature requires an increase in material thickness for the same allowable temperatures to be reached simultaneously in all three materials. It is therefore of interest to investigate the effect of these variables on systems of equal weight.

b. Duration Capability for Systems of Constant Weight

The manner in which chamber pressure and gas temperature affect duration for systems of equal throat weight per unit length is shown in Figure 6. Nozzle duration capability is plotted for the tungsten-asbestos phenolic-steel system as a function of the design variable, for constant throat weight per unit length. The curves show a significant decrease in duration capability with an increase in either chamber pressure or gas temperature. This decrease becomes more marked at higher durations. Also shown on these curves is the optimum duration. At or near the optimum line, the direction of curvature changes. Above the optimum point, weight increases very rapidly for small increases in duration. A similar curve could be drawn for throat diameter, showning a generally similar trend.

c. Maximum Duration Capability

While the optimum duration is a practical indication of duration capability of a particular system at specified conditions, operation above the optimum may sometimes be necessary. Above the optimum, nozzle duration can be extended a short time by increasing the flame barrier thickness. Eventually, a point would be reached when any further increases in flame barrier thickness would not result in an increase in the time necessary for the surface temperature to reach a predetermined value (the maximum allowable material temperature). Finding this maximum duration is equivalent to the problem of heat transfer to an infinitely thick hollow cylinder, which was solved by Carslaw and Jaeger (1). The solution is plotted in Figure 7.

H. S. Carslaw and J. C. Jaeger, <u>Conduction of Heat in Solids</u>, 2nd Edition, p. 338.

Application of this solution to the reference case shows that the maximum duration for the tungsten-asbestos phenolic-steel system lies between 210 and 280 sec (the curve cannot be read any more accurately in this region). The optimum duration for this case is 120 sec.

d. Effect of Radius of Curvature at Throat

The effect of the radius of curvature at the throat was determined by comparing temperature histories of nozzles with different ratios of throat radius of curvature-to-throat radius. The heat transfer calculations in this case were two-dimensional asisymmetric. Results for the tungstenasbestos phenolic-steel system are shown in Figure 8. The curves in Figure 8 show temperature-time distributions in the throat sections of nozzles with radius ratios of 0.5, 2, and infinity; the case for infinity corresponds to a hollow cylinder. The nozzle configurations are shown in Figure 9. Each nozzle has a 15-degree exit-cone half-angle and a 29-degree approach-section angle. The difference in surface temperature which results from using two different radius ratios (0.5 and 2.0) is approximately 1%, and the difference in duration which results is approximately 8%. A similar curve was calculated for a nozzle with a bell-shaped exit section but is not shown. It would lie between the cases for radius ratios of 0.5 and 2.

The curves shown in Figure 8 also provide a comparison between one- and two-dimensional heat transfer calculations. The surface temperature calculated assuming one-dimensional heat transfer is 3.2% lower than the closest two-dimensional case, and the duration is nearly 40% greater (based on the two-dimensional case). This result is not universal for all one-vs two-dimensional heat transfer calculations, however. The size and shape of the nozzles being compared are important factors. For example, in the two test nozzles for which both one- and two-dimensional heat transfer calculations were made, the temperature calculations assuming one-dimensional heat transfer was slightly higher.

2. Effect of Material Variables

a. Thermophysical Properties

The material variables of primary interest are the thermophysical properties -- thermal conductivity, the product of density and specific heat (ρ c_D), and the maximum allowable material temperature.

The effects of the thermophysical properties on optimum duration are shown graphically in Figure 10. Optimum duration is plotted as a function of thermal conductivity for two products of density and specific heat for the insulator and the flame barrier.

The products of density and specific heat shown are approximately equivalent to those for tungsten (41.3 Btu/cu ft-°F), titanium carbide (76.5 Btu/cu ft-°F), asbestos phenolic (41.9 Btu/cu ft-°F), and porous silicon carbide (12.5 Btu/cu ft-°F). The other figures shown on the graph are throat weight per unit length.

The curves in Figure 10 show that, for the insulator, a change in either thermal conductivity or the product of density and heat capacity has a negligible effect on optimum duration, while an increase in thermal conductivity of the flame barrier results in a very great increase in optimum duration. Also, an increase in the product of density and specific heat in the flame barrier results in a significant increase in optimum duration. Increases in optimum duration, resulting from increases in thermal conductivity are accompanied by increases in nozzle weight.

Although it may seem unusual to be able to increase duration capability by using a "poorer" insulator, the reason is quite clear. As insulator conductivity increases, heat is transferred from the flame barrier more rapidly; the time required for the flame barrier to reach its limiting temperature is therefore increased.

All of the weight calculations shown in Figure 10 were made for one insulator density and one flame barrier density. The weight decrease shown for different products of density and heat capacity, therefore, represents the influence of heat capacity only. Although the change in weight is small, and it is reasonable to expect that the material system capable of absorbing more heat will weigh less to do the same job, an increase in specific heat is the only means by which ultimate capability (as indicated by optimum duration) can be increased with a corresponding decrease in nozzle weight.

The weights shown in Figure 10a were calculated by assuming a density of 110 lb/cu ft for the insulating material. Usually insulators with a low value of the product of density and heat capacity have lower densities, while those with a higher value (of about 50 to 60 Btu/cu ft °F) tend towards higher densities (Table 2). The weights shown in Figure 10 could be reduced by 1.5 lb/in. by substituting a low-density insulation and increased as much as 6 lb/in. by substituting a high-density insulation. The flame barrier density is 1170 lb/cu ft. Flame barrier densities vary much more widely and have a much greater effect on nozzle weight than do insulator densities.

To dissociate the effects of the thermophysical properties on duration and weight, duration was plotted as a function of conductivity for systems of equal weight. The resulting curves are shown in Figure 11.

At low thermal conductivity levels, increases in flame barrier conductivity are indicated by the curves in Figure 11 to result in increases in duration capability. At moderate and high conductivities, further increases in conductivity have a negligible effect on duration. Duration drops off sharply after the limiting temperature of the insulator is reached, because the flame barrier is then operating below its allowable maximum.

As the nozzle weight (flame barrier thickness) is increased, the value of flame barrier conductivity above which there can be no further increases in duration is also increased.

b. Maximum Allowable Material Temperature

The proper choice of maximum allowable, or limiting, material temperature is based on knowledge of the behavior of the material at conditions under which it will be used. Choice is also dependent upon the function of the material in the system. The temperature limitation of the flame barrier is thus below the melting temperature and is influenced by the melting or softening point and by design conditions such as chamber pressure and material thickness. The limitation of the heat sink and insulator is the temperature above which these components can no longer transmit pressure forces to the load-bearing member. Since these materials are in the interior of the system, the possibility of decomposition must also be considered. The load-bearing member is limited by the relationship between temperature and yield strength.

In this study, the choice of maximum allowable flame barrier and heat sink temperatures was somewhat arbitrary, being based on limited knowledge of material behavior at very high temperatures. Some value close to and below the melting point was chosen. For the plastic insulators, asbestos phenolic for example, 3000°F was chosen as the limiting temperature.

Although the phenolic resin begins to decompose at approximately 600°F, this insulation material has been successfully tested by Aerojet-General at temperatures above 3000°F when the nozzle design included passages for the escaping gas. The limiting temperature of the load-bearing member was taken as the temperature at which the slope of the yield strength curve changes sharply.

It was not the object of this study to provide sufficient information about material behavior so that a proper choice of limiting temperature may be made. What was determined, however, was the effect of a change in the choice of maximum allowable material temperature on duration and weight, once such a choice has been made.

In Figure 12, throat weight per unit length is plotted as a function of duration for the reference system and design conditions. With the allowable temperature of the insulator kept constant at 3000°F, the allowable temperature of the flame barrier was decreased to 5800°F. With the allowable temperature of the flame barrier kept constant at 6100°F, the insulator allowable temperature was varied to 1500°F and 4000°F.

Increasing the limiting temperature of the flame barrier increases the duration or decreases the weight for the same duration, at durations above the optimum. At or below the optimum duration, an increase in the limiting temperature of the flame barrier has no effect on weight or duration because the limiting temperature is not reached in the flame barrier. The maximum duration of the system with a 5800°F allowable flame barrier temperature is approximately 95 sec, as compared to more than 200 sec for the system with a 6100°F limitation.

Increases in allowable insulator temperatures also result in duration increases and weight decreases, but only at durations below the optimum. At or above the optimum, the limiting insulator temperature is not reached, so any increases in the allowable temperature have no effect. Increases in insulator allowable temperature actually result in decreases in optimum duration, because the portion of the curve above the optimum is extended downward to the new allowable temperature. The effect of an increase in insulator allowable temperature becomes smaller at higher allowable temperatures.

Maximum allowable material temperature is an important material property only in its relationship to the gas temperature. For example, if the allowable temperature of the material were high in comparison to the gas temperature, the duration would be longer, or the nozzle would weigh less, than if the allowable material temperature were low. The relationship between the maximum allowable flame barrier temperature and the gas temperature may be expressed as a dimensionless temperature ratio,

$$\phi$$
, where $\phi = \frac{T_{gas} - T_{allow}}{T_{gas} - T_{o}}$.

Raising the allowable flame-barrier temperature has very nearly the same effect on weight and duration as lowering the gas temperature. For example, a gas temperature of 8000°F and an allowable temperature of 7000°F corresponds virtually to a gas temperature of 7000°F and an allowable temperature of 6126°F. The two cases will be almost exactly the same if the allowable insulator temperature is also changed, so that the dimensionless temperature ratios based on insulator allowable temperatures are equal in both cases. Otherwise, there will be a difference of several hundred degrees between the attained and allowable insulator temperatures. This assumes that very small changes in insulator thickness are required to maintain the load-bearing member at its allowable temperature, with a resultant negligible weight change.

The effect of dimensionless temperature ratio on optimum duration is plotted in Figure 13 for a simulated tungsten flame barrier. The flame barrier properties were identical with those used for tungsten, except that the maximum allowable temperature was varied from 4700 to 7000°F. Although the high value is considerably higher than the melting point of tungsten, its use is justified because the object here is to investigate the trend of the curve rather than the performance of any specific materials.

The curves in Figure 13 are for allowable insulator temperatures of 1500, 3000, and 4000°F at a chamber pressure of 1000 psia. The curves take the same shape as the curve of optimum duration vs gas temperature. As the maximum allowable flame-barrier temperature approaches the gas temperature, the optimum duration increases very rapidly. The increases in optimum duration are, as usual, accompanied by weight increases, but the weight increases become smaller as ϕ approaches zero.

C. FOUR-MATERIALS SYSTEMS

1. Use of a Heat Sink

A heat sink in a nozzle materials system will:

- a. absorb heat entering the system and keep it from reaching the insulator,
- b. keep the flame barrier cooler than if it were backed by an insulator alone, and
- c. reduce the weight of the system when it replaces part of the higher-density flame barrier. A heat sink should be used when:

II, C, Four-Materials Systems (cont.)

- (1) the flame barrier cannot absorb enough of the heat entering the system to protect the insulator,
- (2) the gas temperature is much greater than the flame barrier allowable temperature, and
- (3) the density of the flame barrier is high in comparison with the density of the heat sink which could replace a portion of it.

The effect of the design variables is essentially the same for the four-materials system as for the three-materials system. That is, chamber pressure and gas temperature have a very pronounced effect on duration capability, and the effect of throat diameter is much less significant, except for very small diameters. This is seen more clearly if the four-materials system is considered as a three-materials system in which either (a) the heat sink and flame barrier are considered as a single flame barrier material or (b) the heat sink is considered as the insulator. The first case would apply when the flame barrier of the four-materials system is very thin and experiences a small temperature drop. The second case applies when the flame barrier is nearly as thick as the heat sink or experiences a large temperature drop.

2. Effect of Material Thickness

The flame barrier thickness in the four-materials system should generally be just sufficient to keep the heat sink from reaching its maximum allowable temperature or to prevent its erosion. The effect of varying the flame-barrier and heat-sink thicknesses was investigated for the tungsten-graphite-asbestos phenolic-steel system. The properties used for graphite were similar to those of ATJ* graphite and are shown in Table 4 with properties used for other heat sinks investigated.

^{*}National Carbon Co. designation

II, C, Four-Materials Systems (cont.)

Figure 14 shows the effect upon duration of increasing heatsink thickness for several constant flame-barrier thicknesses. Increasing the
thickness of the heat sink results in a duration increase and a reduction in the
heat sink-to-insulator interface temperature. The curve in Figure 14 also
shows the duration increase which results when the temperature at the heat
sink-to-insulator interface is kept constant and the flame-barrier surface
temperature is permitted to increase to 6100°F. As the flame barrier is
thickened, the duration capability is also increased. However, the nozzle
weight increases more rapidly with increasing flame-barrier thickness than
with increasing heat-sink thickness, because the specific heat of graphite is
more than ten times as great as the specific heat of tungsten. Since the product of density and specific heat is approximately equal for both tungsten and
graphite, the total thickness of the flame barrier and heat sink remains essentially equal at any duration.

3. Effect of Material Properties

The effect of heat-sink material properties on duration capability was studied by comparing the performance of the four heat sinks shown in Table 4. In addition, a second value was used for the thermal conductivity of graphite. The results are shown in Figure 15.

A comparison of the curves for graphite shows the effect of doubling the thermal conductivity. For small heat-sink thicknesses, the effect of conductivity is negligible. At thicknesses of 1.5 in. or greater, the nozzle system with the more highly conductive heat sink has a greater duration capability; this effect increases with increased heat-sink thickness.

II, C, Four-Materials Systems (cont.)

The curves for the beryllium oxide and boron carbide heat sinks again show the effect of thermal conductivity for heat sinks with nearly equal products of density and specific heat. Here the advantage of using the higher-conductivity material starts to become significant at 1.2 to 1.5 in.

A comparison of the curves for the low-conductivity graphite and beryllium oxide shows the effect of nearly doubling the product of density and specific heat while keeping the thermal conductivity constant. Both curves appear to flatten out at approximately the same heat-sink thickness, but the curve for the material with the higher product of density and specific heat shows a maximum of 46% greater duration capability based on the lower duration.

The curves for boron carbide and high conductivity graphite also show the effect of the product of density and specific heat. The conductivity of boron carbide is 22% lower than that used for the high-conductivity graphite and the product of density and specific heat is 87% higher. Durations with the boron carbide heat sink are as much as 50% higher for the same thickness.

Again, the strong effect of the product of density and specific heat is seen in a comparison of the curves for boron carbide and pyrolytic graphite, with the graphite oriented so that the high conductivity is in the radial direction. The product of density and specific heat of the boron carbide is 16% higher, but the thermal conductivity is 80% lower; yet the nozzle system with the boron carbide heat sink shows durations almost as high, and higher, than the one with pyrolytic graphite, for thickness up to 3 in. This result corroborates the finding for the three-materials system: increases in flame barrier thermal conductivity have an insignificant effect upon duration when the conductivity is already very high (see Figure 10).

II, Analytical Studies (cont.)

D. EFFECT OF UNCERTAINTIES IN PHYSICAL PROPERTIES

As materials for use at high temperatures are developed, the question arises of how accurately one needs to know the thermophysical properties to design a nozzle materials system.

The effect of thermal conductivity, density, and heat capacity on temperature distribution is a function of the heat transfer to, and geometry of, the system. These may be expressed in terms of three dimensionless moduli:

- 1. the Fourier modulus, $F = \frac{k \theta}{\rho c_p b^2}$
- 2. the Biot modulus, $B = \frac{hb}{k}$, and
- 3. the radius ratio $R = \frac{a}{b}$

The density and heat capacity affect temperature distribution only through the Fourier modulus, whereas the thermal conductivity affects temperature distribution through both the Fourier and Biot moduli. The effect of errors in density and specific heat on temperature distribution was found for a material insulated on the outside; temperature tables for internally heated hollow cylinders (1) were used along with the following equation (2):

$$\frac{\mathbf{F} + \Delta \mathbf{F}}{\mathbf{F}} = \frac{1}{1 + \frac{\Delta \rho}{\rho} + \frac{\Delta c_{\mathbf{p}}}{c_{\mathbf{p}}}}$$

1. G. Fluke, Temperature Tables for Internally-Heated Hollow Cylinders,
Aerojet-General Corporation, Technical Memorandum 121-SRP, October
1959 (Aerojet-General internal publication).

2.
$$F = \frac{k\theta}{\rho c_p b^2}, F + \Delta F = \frac{k\theta}{(\rho + \Delta \rho)(c_p + \Delta c_p) b^2} = \frac{k\theta}{(\rho c_p + \Delta \rho c_p + \rho \Delta c_p + \Delta \rho \Delta c_p) b^2}$$
$$= \frac{k\theta}{\rho c_p b^2 (1 + \frac{\Delta \rho}{\rho} + \frac{\Delta c_p}{c_p})}, \frac{1}{1 + \frac{\Delta \rho}{\rho} + \frac{\Delta c_p}{c_p}} = \frac{F + \Delta F}{F}$$

II, D, Effect of Uncertainties in Physical Properties (cont.)

The effect of large errors in thermal conductivity cannot be found by this method because a linear combination of errors in the Fourier and Biot moduli yields an accurate result for only very small errors in conductivity. The effect of conductivity errors was found by comparing the results of several computer runs in which only the thermal conductivity was changed.

Fourier numbers of interest in solid-rocket nozzle heat-transfer range from about 0.005, for nonconductive materials with large diameters or at small times of a few seconds, to about 2, for conductive materials with small diameters and long durations of approximately 100 sec. Biot numbers range from about 0.8 for low chamber pressures, small diameters, and high conductivities, to about 150 for high chamber pressures, large diameters, and low conductivities.

Figure 16 shows the effect of errors in density and heat capacity on exposed and insulated surface temperatures for B=10, R=0.8, and F=0.05 and 0.10. This combination of conditions would apply to an 8-in. thick tungsten, hot-flow tested at a pressure of 750 psi at 30 and 60 sec. The gas temperature for this case is $7000^{\circ}F$, but other calculations show that gas temperature has a negligible effect upon the percentage error.

Figure 16 shows that errors in either density or specific heat of 20% or less result in surface temperature errors of less than 5%. The effect of errors in density or specific heat decreases with increasing Fourier number: at the higher Fourier number a 40% error results in less than a 5% error in surface temperature. Also, positive errors in density or specific heat (values greater than the actual) result in negative errors in temperature (values less than the actual) and vice versa.

II, D, Effect of Uncertainities in Physical Properties (cont.)

The effect of thermophysical property errors on temperature is much greater at the insulated than at the exposed surface. The curves of Figure 16 also show that the insulated surface temperature error which arises as a result of errors in density or heat capacity is 2 to 2.5 times greater than at the exposed surface. For the same conditions, the effect of errors in thermal conductivity on surface temperature is negligible. A positive error of 50% or a negative error of 25% in conductivity results in a surface temperature error of less than 1%. Insulated-surface temperature errors which arise from thermal-conductivity errors, shown in Figure 17, are many times greater.

Errors in duration that arise from density or heat capacity errors will have the same magnitude and direction as the errors in density or heat capacity. This is a direct result of the fact that time appears only in the denominator.

For the conditions discussed, positive and negative conductivity errors of 20% will result in duration errors of -8% and 12%, respectively.

An examination of many curves of thermophysical properties as a function of temperature shows that, on the average, the variation in thermal conductivity between room temperature and several thousand degrees is approximately 2 to 2.5 times as great as the variation in heat capacity and 40 to 50 times as great as the variation in density. Although the exact magnitude of the error will depend on the specific heat transfer conditions involved, generally errors resulting from uncertainties in thermal conductivity and heat capacity at elevated temperatures are of the same order of importance, whereas errors resulting from uncertainties in density are important only for the most precise calculations.

II, D, Effect of Uncertainities in Physical Properties (cont.)

The use of constant, as opposed to variable, thermal properties was also investigated for the basic system. In most heat transfer calculations, constant thermal properties are used because of the added complexities of handling variable properties. Sometimes, large errors can result if the constant properties are not chosen properly. In this case, as shown in Figure 18, only a small difference resulted when constant properties were used. The difference increases in going towards the outside of the nozzle.

E. EFFECT OF ANISOTROPY

The recent development of pyrolytic graphite, a material that has considerably different thermal conductivities along different axes, has created interest in the use of anisotropic materials for nozzles. Since the initial announcement of the development of pyrolytic graphite approximately 2 years ago, work has been conducted on the development of a group of other high-temperature anistropic materials, pyrolitic carbides (1). Under the current program, an effort was made to show the possible advantages of using either a material which is inherently anisotropic or a design in which anisotropy is figuratively inferred.

Most present-day nozzle designs that incorporate pyrolytic graphite make use only of its high-temperature limitation and its insulative qualities. For example, it may be used as a very-high-temperature insulator or as an insulating flame barrier to block heat transfer to the wall. Its use as a flame barrier at the throat, however, is in question because the hot surface heats up quickly to within a few hundred degrees of the gas temperature while the surface furthest from the gas remains cool; a serious thermal shock problem is the result.

^{(1).} Being developed by Raytheon Company Research Division, Waltham, Massachusetts.

II, E, Effect of Anisotropy (cont.)

For this study, a conceptual nozzle design was made that uses the high thermal conductivity of pyrolytic graphite parallel to the grain. This design is shown in Figure 19. The nozzle throat is tungsten and the rest of the nozzle is made of graphite and pyrolytic graphite, with an asbestos phenolic insulator and a steel load-bearing member. The pyrolytic graphite is oriented so that the highest conductivity is in the direction parallel to its longest axis. The pyrolytic graphite acts as an insulating flame barrier along the surface of the nozzle in the upstream and downstream sections and, in the interior, conducts heat away from the tungsten throat to cooler portions of the nozzle. The pyrolytic graphite on both sides of the tungsten conducts heat away from the hot surface and prevents heat from entering the tungsten throat area from the side. (Considerable modifications would probably have to be made before such a nozzle could be built.)

Temperature distribution in the nozzle is shown at 93 sec, when the tungsten surface temperature reaches 6100°F (Figure 20a). For comparison, the temperature distribution in a similar nozzle, with all the pyrolytic graphite replaced by ordinary graphite, is shown in Figure 20b. The temperatures reached in the nozzle with pyrolytic graphite are 470 to 600°F lower than those in the nozzle without pyrolytic graphite. The tungsten throat of the nozzle shown in Figure 20b reached 6100°F at its surface within 53 sec. A portion of the pyrolytic graphite section that shows temperatures of 6800°F would have eroded by 93 sec, but this should not seriously affect the condition at the throat. The high temperatures at the graphite-asbestos phenolic interface indicate that either an insulator with a higher maximum allowable temperature (for example, pyrolytic graphite) or thicker graphite should be used.

III. TEST PROGRAM

A. TEST OBJECTIVES

The objectives of the test program were to determine the effects of flame barrier and insulation thickness upon duration capability, to establish the proximity of actual to calculated temperature distributions, and to investigate the effect of aluminum oxide deposition on materials system capability.

B. NOZZLE DESIGN

Six nozzles of 0.70-in. throat diameter were tested. The three-material model was used for the nozzle, and the flame barrier and insulator throat thicknesses were varied. The nozzle consisted of a tungsten flame barrier, a zirconium oxide insulator, and a chrome-molybdenum (4130) steel load-bearing member. Flame barrier thicknesses at the throat varied from 0.150 to 1.00 in., and insulator thicknesses varied from 0.155 to 0.55 in. The insulator thicknesses was at least large enough to maintain the steel at its maximum allowable temperature of 700°F. Steel thicknesses were 0.11 in., except for the nozzle with the thinnest throat, where design considerations necessitated a 0.23-in. thickness. Also because of design considerations, the steel member was omitted from the nozzle with the thickest throat. Figure 21a is a sketch of the basic materials system tested. The nozzles with the two thinnest throats were of slightly different design. These are shown in Figures 21b and 21c.

The entrance section consisted of a thin graphite cone, cemented inside a precast zirconium oxide shell. Use of a large heat sink in the entrance section was deliberately avoided.

III, B, Nozzle Design (cont.)

The tungsten throat insert was machined from a forging of 95+ percent theoretical density and a purity of 99.75%, certified by the vendor. (1) The tungsten was flame sprayed on the outside with zirconium oxide (Rokide Z) of 72- percent theoretical density. A steel sleeve was cemented to the outside of the oxide coating. Flat-bottomed thermocouple holes were then drilled to various depths. The entire nozzle throat assembly was made by the same vendor.

C. TEST CONDITIONS AND EQUIPMENT

1. Test Conditions

The propellant consisted of a polyurethane rubber matrix containing ammonium perchlorate oxidizer and 16% aluminum. Nominal chamber pressure was 350 psi. The calculated combustion temperature was 5750°F at 1000 psi and the actual temperature was estimated to be 5600°F at 350 psi. Nominal firing durations for the motor were all higher than calculated expected durations for the nozzle, assuming no aluminum oxide deposition, and ranged from 50 to 110 sec.

2. Test Rocket Motor

The test rocket motor contained an end-burning grain and had a nominal diameter of 8 in. Nominal length was about 25 in. and firing durations were increased by using a longer chamber. The chamber was made of steel pipe and was water-cooled during the test.

⁽¹⁾ Straza Industries, El Cajon, California

III, C, Test Conditions and Equipment (cont.)

The steel aft closure shown in Figure 22 was designed to accommodate thermocouples. The nozzle assembly was cemented to the aft closure, which was bolted to the motor. Figure 23 is a photograph of a typical aft closure assembly before firing. The thermocouple connection plugs are shown wrapped with insulation material.

3. Instrumentation

Pressure was measured with a Taber pressure transducer by means of a pressure tap in the aft end of the chamber. This was connected to a continuous recorder. Two readings were taken and averaged.

Each nozzle was instrumented with six thermocouples, all located at the throat at various depths. Four types were used: tungsten/tungsten-26% rhenium, tungsten/rhenium, platinum/platinum-13% rhodium, and chromel/alumel.

The use of tungsten-type thermocouples represented an attempt to measure temperatures above 3200°F near the hot surface of the flame barrier. Neither of the two tungsten/tungsten-rhenium thermocouples (1) produced any usable results. The tungsten/rhenium thermocouples (1) were insulated with beryllium oxide and were assumed to be reliable up to 4000°F; one of the 10 used was chosen at random and calibrated between 2000 and 4000°F. The calibration data agreed very well with the accepted calibration curve for tungsten-rhenium. During the tests, some of these thermocouples showed signs of erratic behavior at about 3000°F.

⁽¹⁾ Continental Sensing, Inc., Melrose Park, Ill.

HI, C, Test Conditions and Equipment (cont.)

Four thermocouples of the first three types were used to measure temperatures in the tungsten. One platinum/platinum-13% rhodium thermocouple measured the temperature in each insulator and the temperatures in each steel section were measured with one chromel/alumel thermocouple. Two thermocouples were placed in the insulator of the nozzle in which the steel load-bearing member was omitted. The thermocouples, except for the tungsten/tungsten-rhenium, were secured with Swagelok fittings (1). Table 5 shows the locations of the thermocouple holes. The radial distances from the nozzle axis were obtained from prefiring measurements of the depths of the holes, the throat radii, and the outside diameter. These were checked against direct measurements of two holes in each nozzle after the nozzle was hot-flow-tested and sectioned. The measurements agreed within 0.005 in.

D. PROCEDURES

Each nozzle assembly was inspected after receipt. The throat diameter was measured to the nearest 0.001 in. and the average of four readings was taken. The depths of the thermocouple holes were measured to the nearest 0.001 in. Photographs of the nozzle and aft closure were taken immediately before and after firing. During firing, the nozzle was photographed with high-speed motion picture and closed-circuit television cameras. After disassembly, each insert was photographed, and the throat contour was traced on transparent paper with an optical comparator at a magnification of 10X. The throat area was then measured from the trace (shadowgraph) with a planimeter. The diameter after firing was calculated by assuming a true circle. The nozzles were cut in half along the long axes and photographed again; each cut was made through two of the thermocouple holes, and the distance to the inside nozzle surface was measured directly.

⁽¹⁾ Swagelok Tube Fittings, Cleveland, Ohio.

III, D. Procedures (cont.)

Temperature distributions were calculated for each nozzle, assuming one-dimensional heat transfer and a heat transfer coefficient based on constant nominal pressure. Two-dimensional, axisymmetric heat transfer calculations were also made for the nozzles with 0.45 and 1.00-in. tungsten throat thicknesses. The calculated temperature distributions were then compared with the thermocouple readings for the nozzles in which no aluminum oxide deposition occurred. Where deposition occurred, the measured temperature data were used to obtain an experimental heat transfer coefficient. The difference in resistance to heat transfer represented by the experimental and theoretical heat transfer coefficients was assumed to be a measure of the resistance offered by the deposited oxide layer. This was compared to the measured deposit thickness and an average thermal conductivity was obtained for the deposit.

E. TEST RESULTS

Photographs taken immediately after testing of each of the six nozzles are shown in Figure 24. (The nozzle shown in Figure 24c is an exception to this statement, as the photograph taken immediately after firing was not usable; the one shown was taken after disassembly of the aft closure.) The nozzles are arranged in order of decreasing tungsten throat thickness. Considerable deposition occurred where the nozzle throats were thick. The thinnest nozzles were burned through during the firing. The test results are summarized in Table 6. Pressure vs time, temperature vs time, and shadowgraphs for each nozzle are shown in Figures 25 through 40. Shadowgraphs were not taken of the two nozzles that burned through during firing. Ignition delays of approximately 10 sec occurred in tests No. 3 and 4 and are shown graphically in Figures 27, 28, 32, and 33.

The amount of aluminum oxide deposition, as determined from the shadowgraphs, is shown as a function of tungsten throat thickness in Figure 41.

F. CORRELATION OF TEST DATA

1. Discussion of Nozzle Burnthrough

The nozzle designs were such that the thinnest sections were upstream of the throat. A hoop-stress calculation shows that 0.08-in.-thick tungsten is required at an area ratio of 3.2, upstream of the throat, for a chamber pressure of 350 psi. The tungsten inserts in the two nozzles that failed during firing were 0.10 and 0.13 in. thick, respectively. These values are represented by safety factors of 1.3 and 1.6. It is postulated that the failure of these two nozzles occurred in the entrance section when the insulation was heated beyond its softening point and could no longer transmit load to the steel. The tungsten, forced to carry the full load, yielded and failed.

Calculations show that the insulator at the throat should reach its assumed limiting temperature of 4600°F at 6 and 14 sec for the 0.15-in. - thick and the 0.30-in.-thick tungsten, respectively. The time for the insulation in the entrance section to reach the same temperature was not calculated, but should be approximately the same, or a little greater, because of the balance between decrease in heat transfer coefficient and decrease in tungsten flame barrier thickness. The pressure and temperature curves indicate that burnthrough started at approximately 1.5 and 3.5 sec after ignition for the nozzles with 0.15-in.-thick and 0.30-in.-thick tungsten, respectively. The starting of burnthrough so soon after ignition could be attributed either to an assumption of too high a value for the limiting insulator temperature or to a slight crack in the tungsten that went undetected because it occurred after assembly. In this

where: P = 0.976 (350) psi

d = t + 0.70 in.

σ = 2000 psi allowable stress for tungsten at 4800°F

 $\phi = 32^{\circ}$ entrance angle

⁽¹⁾ $t = \frac{Pd}{2\sigma \cos \phi}$ = wall thickness, in.

III, F, Correlation of Test Data, (cont.)

instance, thermal shock was discounted as a reason for failure because the thickest nozzles, which remained intact, should have suffered the most severe shock.

The next larger insert (0.45-in. tungsten throat thickness) was 0.13 in. thick at its thinnest section. Although the throat remained intact, a portion of the entrance section was burned through to the steel shell (Figure 42).

2. Comparison of Calculated Temperatures with Test Data

For the two thinnest nozzles, calculated temperatures and the test data agree fairly well, but, because of deposition, the results for the other nozzles show consistently lower temperatures than calculated.

In tests No. 4 and 5, the two thinnest nozzles, the thermocouples in the tungsten at the section where burnthrough occurred show lower temperatures than those on the opposite side and show the greatest temperature rise after burnthrough started, as indicated by the pressure curves. These thermocouples were probably not operating after about 3.5 sec and are not represented on the comparison curves. In addition, TN 3 on test No. 4 was inoperative and is not shown.

In test No. 4, where 0.030-in.-thick tungsten was used, agreement was excellent for thermocouples TN 1 and TN 2 (Figure 43). The calculated temperatures began at the end of the ignition delay of 9.7 sec. After 30 sec, the pressure was very low, with a corresponding reduction in heat transfer coefficient. This probably accounts for the leveling off of the temperature shown by TN 3.

In test No. 5, where 0.15-in.-thick tungsten was used, agreement was fairly good for TN 1 and TN 2 (Figure 44). The measured

.III, F, Correlation of Test Data

insulator temperature (TN 3) was far below the calculated value; the discrepancy is probably a result of improper installation of the thermocouple. The insulator material is such that particles come off when it is scraped. The scraping action of the thermocouple when installed could easily rub off enough particles to cause a large displacement of thermocouple location. A difference of 0.03 in. in location could result in temperature error of 25%.

A two-dimensional heat transfer calculation made for the nozzles of tests No. 1 and 2 and shown in Figures 45 and 46 account for only a very small portion of the difference between measured and calculated temperatures. The remainder of the difference was ascribed to aluminum oxide deposition. An attempt was made to determine an average heat transfer coefficient for the entire firing time by comparing the measured data with temperature distributions calculated by assuming various heat transfer coefficients as shown in Figure 47. The result was an "experimental heat transfer coefficient" (h exp). Assuming a steady-state condition exists between the film and the wall, the difference between reciprocals of the experimental heat transfer coefficient and the heat transfer coefficient calculated from the average chamber pressures should be equal to the average thermal resistance of the aluminum oxide film. The film resistance is compared with the average film thickness, and a film conductivity (k,) is calculated. The average film thickness is taken as half the thickness measured after firing. The calculation is summarized in Table 7. Values of k_f found by this method average 5.4 Btu/hr-ft-*F. The best available data for solid aluminum oxide (1) show conductivities of about 5.8 Btu/hr-ft-*F for the dense material, when the data are extrapolated to the melting point; this is an excellent agreement. No data are available for the conductivity of molten aluminum oxide. This calculation demonstrates that temperature data and deposition thickness can be correlated.

⁽¹⁾ A. Goldsmith and T. E. Waterman, Thermophysical Properties of Solid Materials, WADC TR 58-475, October 1958, p. VII-M-1.

IV. CONCLUSIONS

A. ANALYSIS

- 1. For a nozzle materials system, an optimum balance between duration and material thickness may be found. This optimum is a practical measure of duration capability; above it, nozzle weight increases rapidly for small increases in duration.
- 2. Optimum duration decreases rapidly with small increases in chamber pressure or gas temperature, but increases in throat diameter for diameters above 4 in. affect optimum duration only slightly.
- 3. In constant-weight systems, increases in chamber pressure or gas temperature result in decreases in duration; the effect is greater at higher durations.
- 4. Flame-barrier and heat-sink thermophysical properties significantly affect duration capability, while insulator and load-bearing member properties do not. Flame barriers should generally have moderately high thermal conductivities, high products of density and specific heat, and low densities. A high product of density and specific heat is more important than high conductivity in selecting heat-sink materials.
- 5. Four-material systems can be designed lighter in weight than three-material systems because heat sinks usually have lower densities than flame barriers.
- 6. Increases in maximum allowable material temperature result in duration increases or weight decreases; the increase or decrease is above the optimum point for the flame barrier and below the optimum for the insulator.

IV, A, Analysis (cont.)

- 7. Thermal conductivity and heat capacity errors that result from uncertainties in thermophysical properties at elevated temperatures are of the same relative order of importance, but errors resulting from uncertainties in density are important for only the most precise calculations. Positive thermal conductivity errors and negative density or heat-capacity errors will result in conservative estimates of duration capability.
- 8. Use of a properly oriented anisotropic material could result in increased duration capability.

B. TEST PROGRAM

- 1. The test data show that it is possible to predict nozzle temperatures fairly accurately only when no deposition occurs on the nozzle wall during firing.
- 2. When deposition occurs, the measured temperature is lower than the calculated value but may be brought very close to agreement by consideration of the deposit thermal blocking effect in the calculation.
- 3. The amount of deposition that occurs during a firing increases as the heat-sink thickness increases, resulting in longer durations than could be achieved with the lower surface temperatures due to increased thickness alone.
- 4. Insulator temperatures are difficult to measure accurately because of the difficulties involved in obtaining a good seat at the bottom of the thermocouple hole and in measuring thermocouple locations accurately.

V. RECOMMENDATIONS

A. MATERIALS RESEARCH AND DEVELOPMENT

The following areas are most promising for future materials research and development, as applied to solid rocket nozzles.

1. Use of the following criteria, listed in order of importance, to determine the potential of future nozzle materials from the heat transfer point of view.

a. flame barriers

- (1) high allowable temperature
- (2) high product of density and specific heat
- (3) moderately high conductivity
- (4) moderately low density

b. heat-sink materials

- (1) high product of density and specific heat
- (2) moderately high conductivity
- (3) low density
- (4) moderately high allowable temperature

c. insulator

- (1) high allowable temperature
- d. load-bearing member
 - (1) low density

V, A, Materials Research and Development (cont.)

- 2. Development of boron carbide for use as a nozzle heat-sink material.
- 3. Development of techniques to manufacture high-temperature anisotropic materials so that either the conducting or insulating properties may be used in any direction desired.

B. NOZZLE BEHAVIOR INVESTIGATIONS

In addition to the above areas for materials research and development, the following areas hold promise for future analytical and experimental investigations to obtain significant knowledge of nozzle behavior:

- 1. Effects of induced thermal stresses, thermal shock resistance of materials, and effects of erosion characteristics on duration capability should be investigated.
- 2. The effects of aluminum oxide deposition should be studied, especially the mechanism of deposition, the properties of the deposit, and the use of the deposit as an auxiliary flame barrier to block heat transfer to the wall.
- 3. Attention should be given to the use of anisotropic features in nozzle design. The use of anisotropic materials is merely a first step in this direction. The possibilities of conducting heat more efficiently to the cooler sections of the nozzle, perhaps with finned flame barriers, should be investigated.
- 4. A more detailed study of weight vs duration, especially as the entire missile system is affected, would be helpful to nozzle design.

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TABLE 1
LIKELY NOZZLE MATERIALS

| | · | |
|-----------------|--|--------------------------------------|
| <u>Function</u> | Material . | Distinguishing Characteristics |
| Flame Barrier | l. Refractory Metals (W, Ta-W, Mo) | High conductivity High density |
| | 2. Graphites | Moderate conductivity Low density |
| | 3. Refrectory Carbides (HfC, TaC, TiC, ZrC) | Low conductivity High melting points |
| | h. Pyrolytic Grephite, Pyrolytic Carbides | Anisotropy |
| Heat Sink | 1. Graphites | High-Temperature Limitation |
| | 2. Beryllium Oxide | High specific heat |
| | 3. Boron Carbide | (>0.4 Btn) |
| Insula tor | l. Plastics (Refrasil or Asbestos Phenolic, Graphite Cloth with Phenolic Resin) | Low conductivity |
| | 2. Ceremics (2r0 ₂ , Al ₂ 0 ₃ , Porous SiC) | Higher temperature limitation |
| Load-Bearing | l. Steels | |
| Hember | 2. Titanium Alloys | Strongth at elevated temperatures |
| | 3. Super-Alloys (Udimet, Hastelloy) | |
| | 4. W-Co Alloys | |
| | | |
| | | |
| | | |
| | | |
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TABLE 2
RANGE OF THEMOPHERICAL PROPERTY DATA FOR HORSLE NATURALS

| Naterial. | Type | k, Ri-IV-Y | Tong.hange | Op. 15-'F | Temp _y Renge | dle, | Nelt Point, 7 | References |
|---------------------------------|---------------------------|---------------------|-----------------|-------------|-------------------------|-------|--------------------|---------------------------------|
| Tengrica | | 110-98 | 70-3500 | 0.03-0.05 | 0-4500 | 1205 | 6170 | 2-4 |
| Tantalus-tungsten | 90Ta-10W | 32.7-19.8 | 2600-5300 | 2.6. | | 1050 | 5500 | 8, Stauffer- Temescal Co. |
| Holy bdomm | | 84-40 | 100-f100 | 0.063-0.125 | 100-1600 | 639 | 4750 | 6 |
| Hafaiwa Carbido | | 5.3 -9 | 582-7686 | 0.055072 | 500-5000 | 760 | 7030 | 5 |
| Tantalum Carbido | | 16.6-31.8 | 533-4240 | 0.05-0.082 | 500-4500 | 899 | 701.0 | 5 |
| Titanium Cartido | 15.66 dense | 15-2.8 | 90-2.8 | 0.14-0.22 | 70-2000 | 306 | 9860 | 3.4 |
| Zireczium Carbido | | 18.3-20 | 100-4300 | 0.091-0.170 | 500-1500 | 417 | 6366 | 5 |
| Oraphite | ATJ | 50-8 | 470-5000 | 0.17-0.5 | 80-3200 | 1.08 | 6600** | 5,National Carbon Co |
| | 27-5001 | 120-26.5 | 70-3500 | 0.2-0.5 | 70-3500 | 127 | 6600 ** | Metional Carbon Co. |
| | Pyrolytic (with grain) | 235-194 | 70-750 | 0.13-0.30 | 70-750 | 140 | 6600 ^{##} | Raythean Co. |
| | (against) grain) | 2.06-0.176 | 70-31-70 | 0.12-0.315 | 70-1470 | 140 | 6600 ** | Raytheen Co. |
| Boryllium Orido | 95% dense | 46 -9 .4 | 400-2550 | 0.25-0.495 | 85-1600 | 179 | 1620 | 3 |
| Boron Carbido | | 70-5-37-5 | 212-1292 | 0.427-0.581 | 80-2600 | 156 | صليانا | 3 |
| istralite (Befresil Phanalia | 1201 | 0.208-0.158 | 0-1000 | 0.2-0.275 | | | | • |
| Asbestos Phanelis | 161-179 | 0.167-0.258 | 100-k00 | 0.197-0.3h | 0-3000 100-400 | 108 | 3000* | 7 |
| Zirconium Ozido | Morton "H" | 0.405-0.662 | 800-3600** | 0.175 | 80-2550 | 200 | 3000+ lideo | John Manville Co. Marten Co. |
| Alveriren Orido | 1.35 demos | 9.6-1.6 | PO-7950 | 0.10-0.184 | 68-3270 | 125 | 3700 | h, 1 |
| Silicon Cartido | 30% dames | 1,5-2 | 800-1900 | 0.16-0.318 | 70-2250 | 60 | | . Carborandon Co. |
| Steel. | 1130 | 24.7 | 70 | 0.107 | 70 | 109.6 | 700* | 9 |
| Inomel z | | 7.74-16.7 | 68-1200 | 0.110-0.115 | 68-1200 | 187 | 1000-1500 | International Michal Co. |
| Pitenium Alley | MM-CNU- C-130AM | 6.3-11.3 | 60-3700 | 0.13-0.207 | 100-150 | 264 | 900+ | 1 |

^{*} at room temperature

References

- 1. Thornal Properties of Cortain Materials, AVOD RAD-FRE-FREEDID, 2 Polymany 1957.
- 2. H. Porter, Rocket Refrectories, MAYORS 5093 (AD-95 502), 26 August 1955.
- 3. Resetor Handbook, Vol. 3, Section 1, AEU, March 1955.
- h. A. E. Coldenith and T. E. Maternas, Thursophysical Properties of Solid Naturals, Mad IR-53-476, October 1998.
- 5. D. S. Heal, C. D. Peare, and S. Oglosby, Jr., The Thermal Properties of Thirteen Solid Materials to 500097 or Their Destruction Tomperatures, MAID 60-9th, November 1940 (Southern Messarch Center).
- 6. A. E. Coldenith and T. E. Waterwen, Thermophysical Properties of Solid Materials, MRDC TR-98-A76, Revised, August 1960.
- 7. H. L. Thompson Company letter to A. Q. Hardrath, Aerojot-General Corporation, 19 August 1959.
- 8. W. F. Remons and R. D. Allen, 50%-100 Alley: Summary of Thermal Properties to Multing Point and Tenetles Properties from 25000 to 1500-7, Lerojot-General Corporation, Entertals Report N-2007, 1980.
- 9. Solid Regime Design Handbook, Aerojet-General Corporation, August 1957.

es sublimates

⁺ meximum allowable

⁺⁺ mean temperatures

TABLE 3

REPRESENTATIVE MATERIAL PROPERTIES OF REFERENCE-SYSTEM MATERIALS

| Material | k, Btu/hr-ft-*F | Pa, Bta/ca ft-*F | Limiting Temp, *F |
|----------------------|-----------------|------------------|-------------------|
| Tungsten | 60•0 | 41.3 | 6100 |
| Asbestos Phenolic | 0.258 | 41.9 | 3000 |
| Steel | 23•7 | 52.4 | 700 |

TABLE 4

REPRESENTATIVE MATERIAL PROPERTIES OF HEAT SINKS

| Material | k,Btu/hr-ft-°F | Pcp, Btu/cu ft-°F | Limiting Temp, *F |
|-------------------------|----------------|-------------------|-------------------|
| ATJ Graphite | 51.6 25.0* | 41. 8 | 6600 |
| Pyrolytic Graphite** | 194 | 67.2 | 6600 |
| Boron Carbide | 140 | 78.0 | j ijt00 |
| Beryllium Oxide | 25 | 72.3 | ù500 |

^{*} second value of conductivity chosen for comparison with BeO.

^{**} oriented so that highest conductivity is in the radial direction.

TABLE 5 LOCATION OF THERMOCOUPLES

| Tungsten Throat Thickness,in. Test No. Thermo- couple No. | | Thermo- couple Type # | Relative Angular Location | Radial Distance from Nossle Axis, in. | Material in Which Located | |
|---|-----|-----------------------------|---------------------------------|---|---------------------------------|-----------------|
| 1 | 1 | 17/1 | WRE | 0* | 0•106 | Tungsten |
| | | 2 | PPR | 60 | 0.792 | Tungsten |
| | | | PPR | 120 | 1.177 | Tungsten |
| | | 4 | PPR | 180 | 1.321 | Tungsten |
| | | 5 | PPR | 21/0 | 1.502 | Zirconium Oride |
| | | 6 | CA | 300 | 1.683 | Steel |
| 0.80 | 6 | 1 | PPR | 0 | 0.471 | Tungsten |
| | | 2 | PPR | 60 | 0.779 | Tungsten |
| | | 3 | PPR | 120 | 1.052 | Tungsten |
| | ı | 4 | CA | 300 | 1,523 | Zirconium Oride |
| | | 5 | PPR | 210 | 1.306 | Steel |
| 2.00 | | 6 | WRE | 180 | 0.484 | Tungsten |
| 0.60 | 3 | 1 | WILE | 0 | 0.1197 | Tungsten |
| | | 5 | WRE | 80 | 0.665 | Tungsten |
| | | | PPR | 120 | 0.870 | Tungsten |
| | | 4 | PPR | 240 | 1.070 | Zirconium Ozide |
| | | _5 | CA | 300 | 1,261 | Steel |
| | | 6 | PPR | 180 | 0.457 | Tungsten |
| 0.112 | 2 | _1 | WRE | 0 | 0.131 | Tungsten |
| | | 2 | WRE | 60 | 0.579 | Tungston |
| İ | - 1 | 3 | PPR | 120 | 0.728 | Tungsten |
| 1 | - 1 | 4 | PPR | 200 | 0.893 | Zirconium Oride |
| 1 | ŀ | _ 5 | CA | 300 | 1.057 | Steel |
| | | 6 | WWITE | 180 | | Tungsten |
| 0.30 | 4 | _1 | WRE | 0 | 0.134 | Tungsten |
| | 1 | 2 | PPR | 60 | 0.569 | Tungsten |
| 1 | - 1 | 3 | PPR | 270 | 0.710 | Zirconium Oride |
| | - 1 | 4 | CA | 300 | 0.855 | Steel |
| | - 1 | _ 5 | PPR | 120 | 0.133 | Tungsten |
| . <u></u> l | | 6 | WRE | 180 | | Tungsten |
| 0.15 | 5 | I | WRE | 0 | 0,380 | Tungston |
| 1 | | 2 | PPR | 60 | 0.480 | Tungsten |
| | l' | 3 | PPR | 240 | 0.566 | Zirconium Oride |
| ļ | | 4 | CA | 300 | 0.777 | Steel |
| į | E | 51 | PPR | 120 | 0.380 | Tungsten |
| | F | 6 | WRE | 180 | 0.476 | Tungsten |

WHE = tungsten/rhenium

WHE = tungsten/tungsten-26% rhenium

PPR = platinum/platinum-13% rhodium

CA = chronel/alumel

ý

SUPPART OF TEST RESULTS TABLE 6

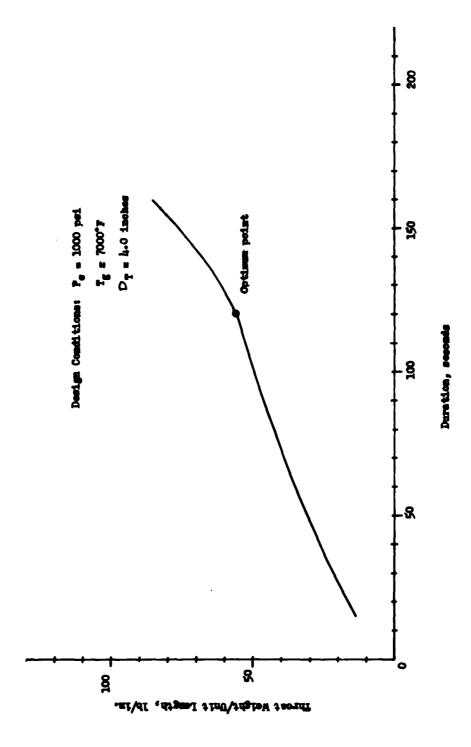
| Ferent | Change of Throat free | -51.0 | -35.9 | 4-96- | -18.97 | • | - | · |
|------------|-----------------------------------|-------|-------|----------|--------|------|-------|---|
| | Throat Dia, in. Before After | 0.lkg | 0.593 | 0.542 | 0.630 | ŧ | | |
| | Throat Before | 969°0 | 0.705 | 969°0 | 00.00 | 0.70 | 0.700 | |
| apa. | Total Duration | 105.0 | 68.3 | 9*19 | 54.7 | 99.1 | 98.3 | |
| TABL. BOCK | At Max Tota | 103.4 | 8.40 | 59.8 | 50.0 | 2.8 | 1.5 | |
| | pete Ave | 503 | 386 | 128 | 325 | 717 | ន្ទ | |
| | Pressure, peta In Max Avg | 8 | 924 | 929 | 380 | 326 | 798 | |
| | r a | 321 | 325 | 305 | 287 | ਤੋਂ | 8 | |
| | Test No. | 1 | 9 | M | 8 | 4 | w | |
| | Tungsten Throat Thickness, in. | 1,00 | 0.80 | 0,60 | 540 | 0°30 | 0.15 | |

TABLE 7

CALCULATION OF OXIDE FILM CONDUCTIVITY FROM TEST DATA

| Caloulated Average Deposit thermal Conductivity Btu/hr-ft-* | 0-1 | 8.1 | ************************************** | ፟ ት | м. Ф.Ф. |
|---|--------|----------|--|--------------------|---------------------|
| Average Deposit Thickness, in. | 0.052 | 0.018 | 0.038 | 0.028 | |
| Average Deposit ormal Resistance, Deposit Inickness 'Btu/hr-ft-'F | 0,105 | 0.035 | 2000 | 950°0 | |
| 육취 | 0,0131 | 0.0022 | 0.006l# 0.0069 | 0.0081* 0.0045+ | |
| Heat Transfer Coefficient Btu/hr-ft2-*; Average Experimental | 550 | 835 | 73 8 * | 640# 715+ | |
| Heet fram Btu/hr Average | 13% | 980 | 1220 | 1122 | |
| Presente, Presente, Per | 563 | % | 921 | . 386 | 7 |
| Run Ho. | ri | ~ | m | • | Average of the true |

*Extrapolated from first two values on basis of flame-barrier thickness *Extrapolated on basis of deposit thickness



 i_{-i}

Figure 1: Minumum Nozzle Weight for Tungsten-Asbestos Phenolic-Steel

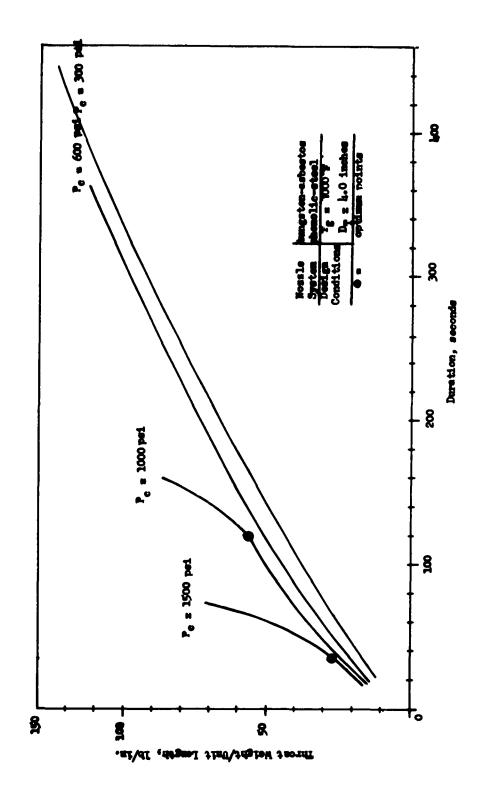


Figure 2: Minimum Nozzle Weight for Various Chamber Pressures

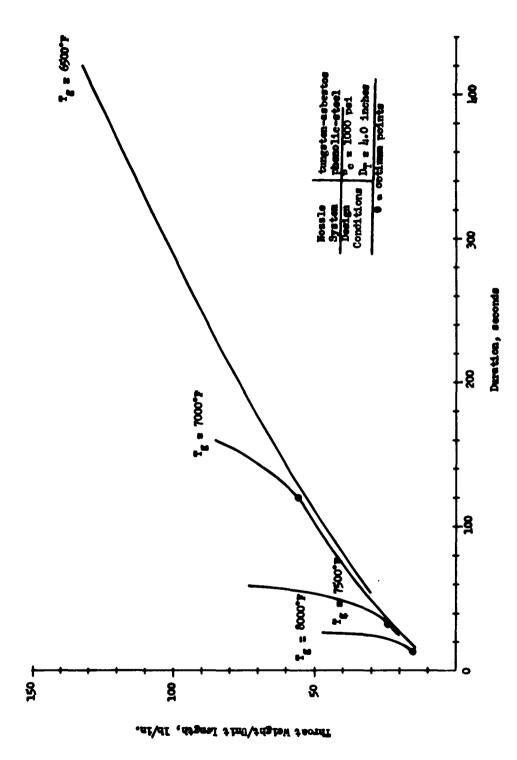


Figure 3: Minimum Nozzle Weight for Various Gas Temperatures

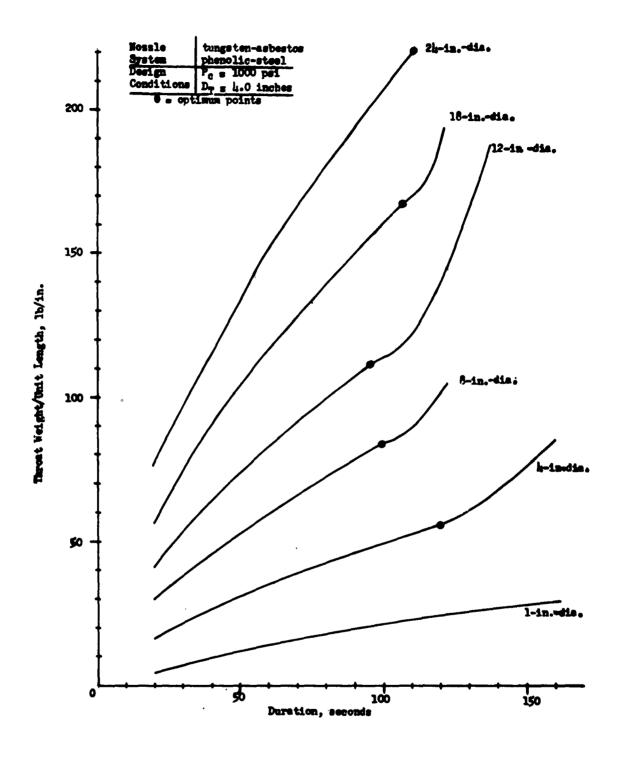


Figure 4: Minimum Nozzle Weight for Various Throat Diameters

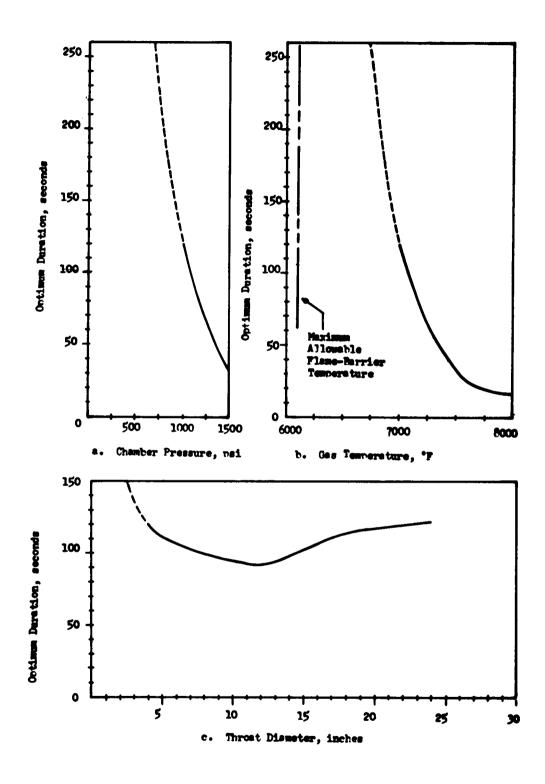


Figure 5: Optimum Nozzle Duration for Several Design Variables

4. As a Punction of Chamber Pressure b. As a Punction of Gas Temperature Mossle Systems tungsten-abbetos phenolic-steel

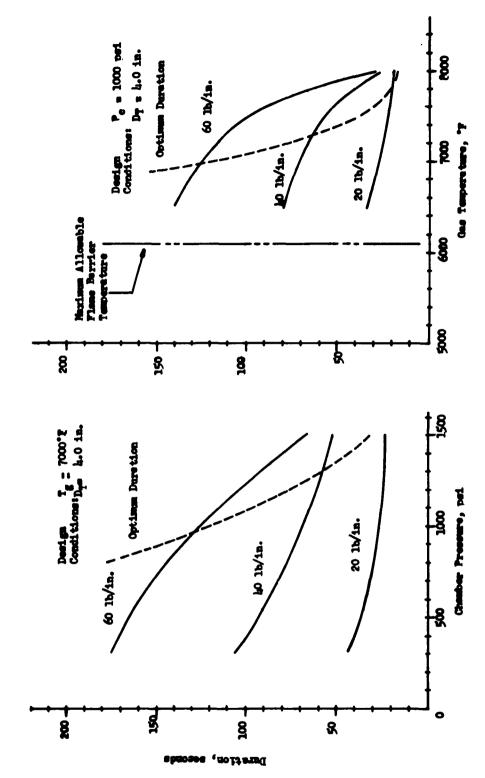


Figure 6: Nozzle Duration Capability for Constant Weight

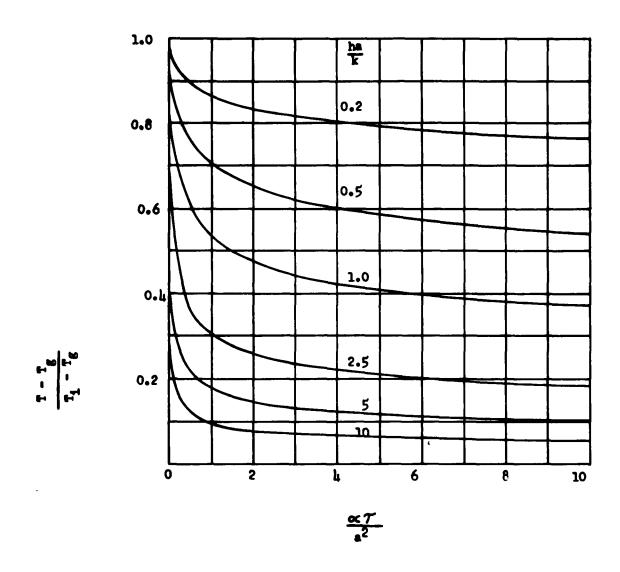


Figure 7: Temperature Distribution in Infinitely Thick Hollow Cylinder

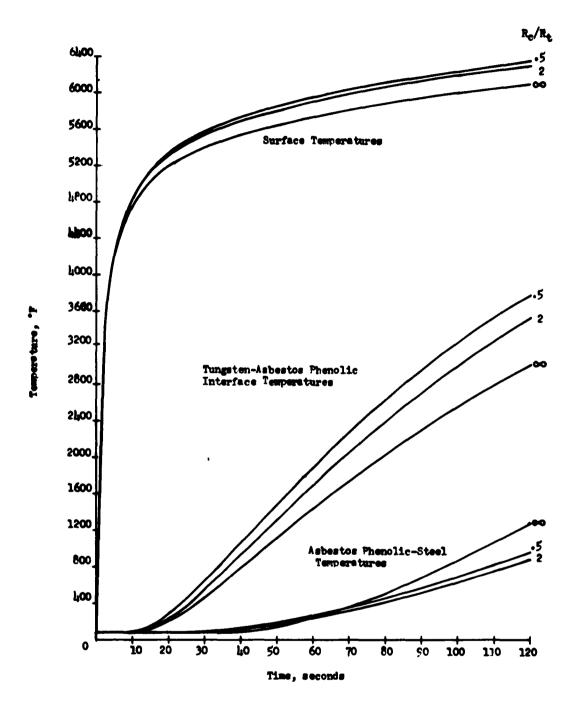
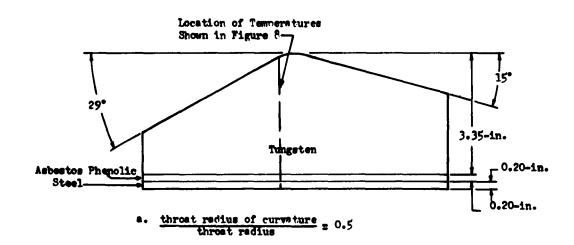


Figure 8: Effect of Radius of Curvature of Throat Upon Throat Temperature





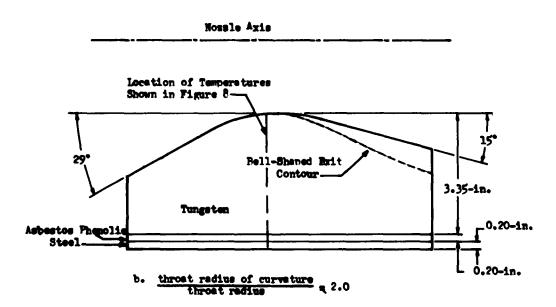


Figure 9: Nozzle Models Used for Calculation of Effect of Throat Radius of Curvature

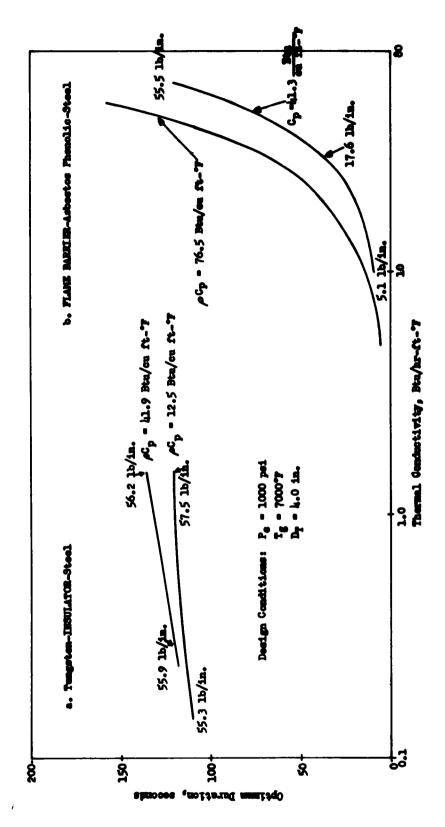


Figure 10: Effect of Thermophysical Properties Upon Optimum Duration

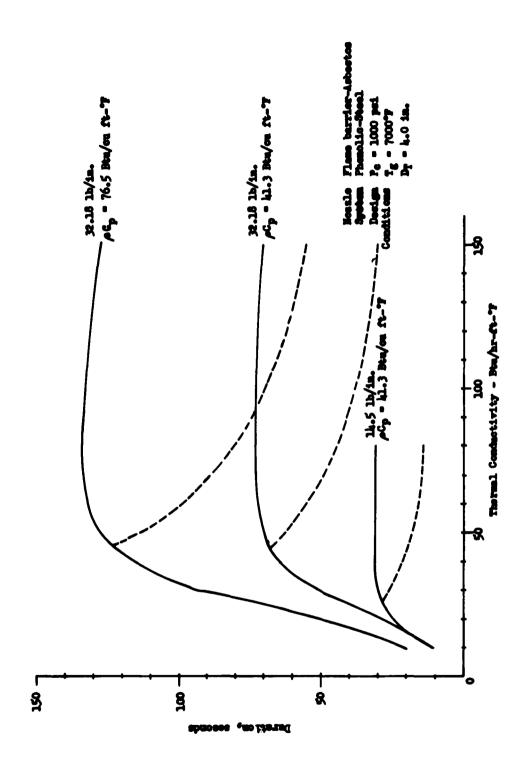


Figure 11: Effect of Thermophysical Properties Upon Duration for Constant Weight Systems

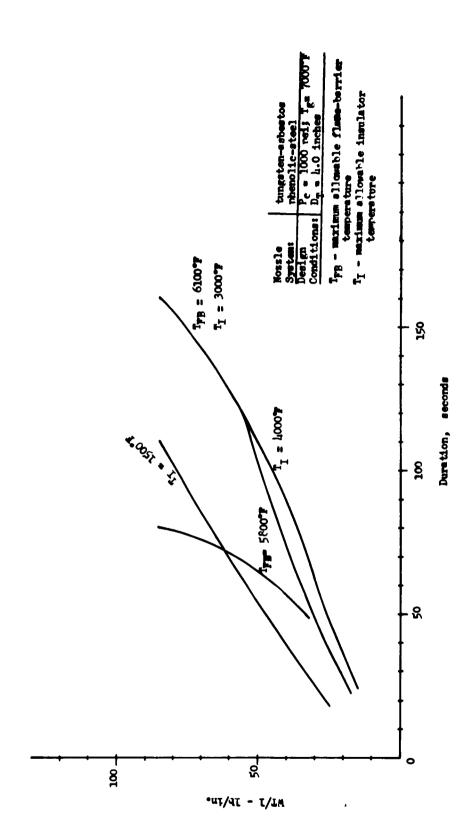


Figure 12: Effect of Maximum Allowable Material Temperature Upon Nozzle Weight and Duration

1

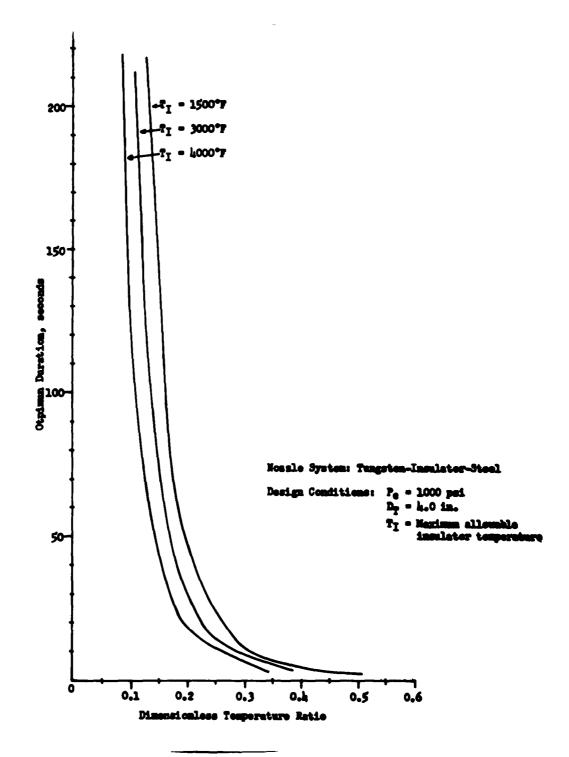


Figure 13: Effect of Dimensionless Temperature Ratio Upon Optimum Duration

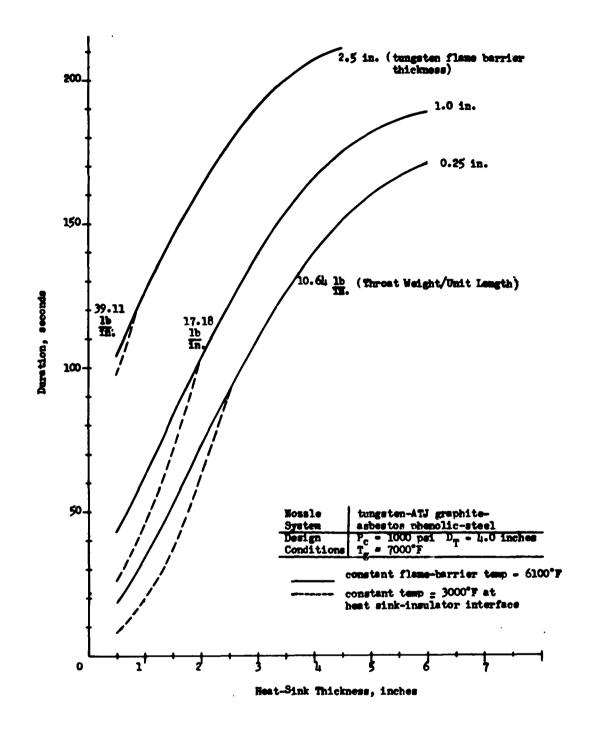


Figure 14: Effect of Heat-Sink Thickness Upon Duration

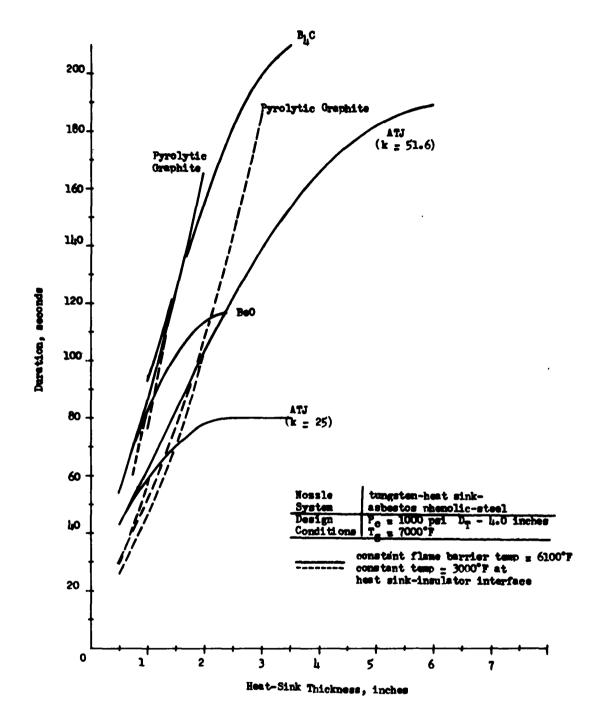


Figure 15: Effect of Heat-Sink Thermophysical Properties Upon Duration

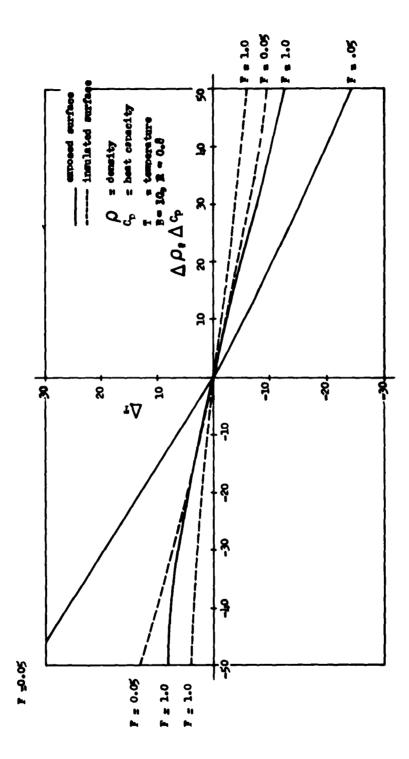


Figure 16: Effect of Density of Heat Capacity Errors Upon Exposed and Insulated Surface Temperatures

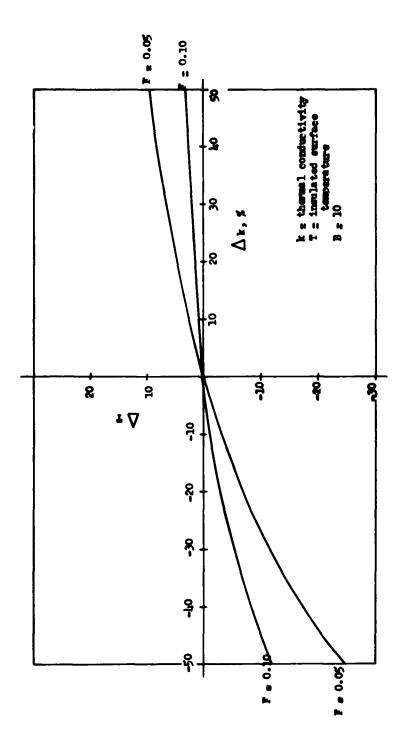


Figure 17: Effect of Thermal Conductivity Errors Upon Insulated Surface Temperature

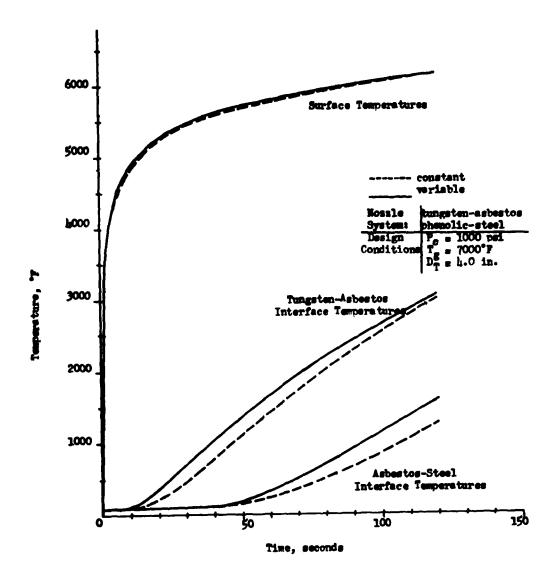


Figure 18: Comparison of Temperature Distributions Calculated by Using Constant and Variable Thermal Properties

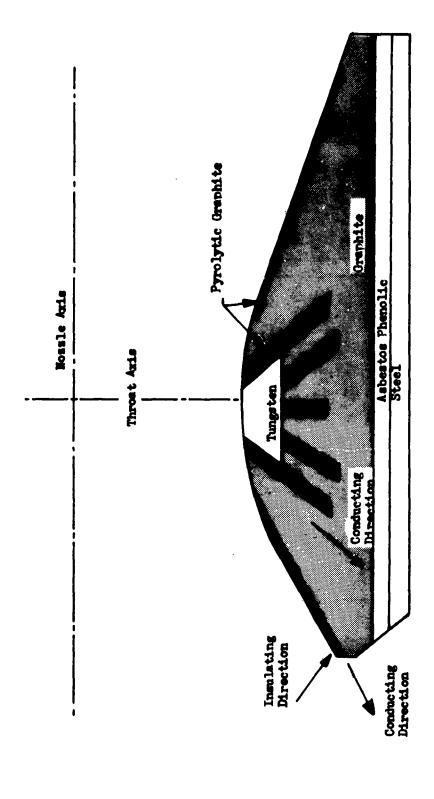
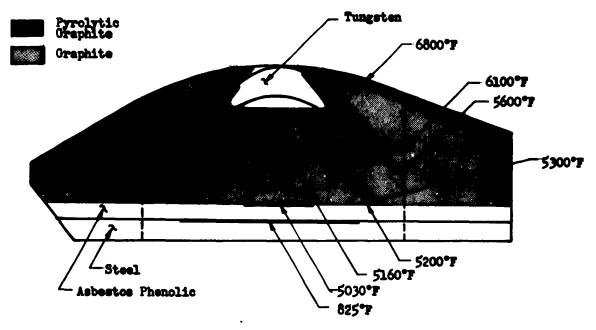
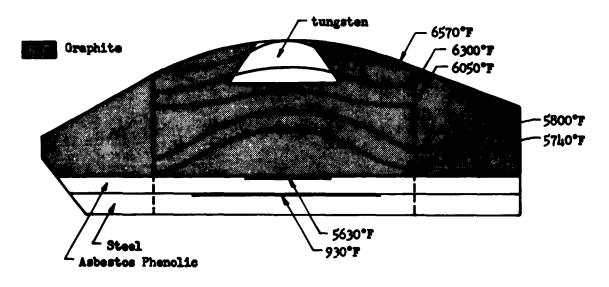


Figure 19: Conceptual Design of Nozzle Utilizing Pyrolytic Graphite

a



a. Nossle with Pyrolytic Graphite



b. Nossle without Pyrolytic Graphite

Figure 20: Comparison of Temperature Distributions at 93 Seconds in Nozzles With and Without Pyrolytic Graphite

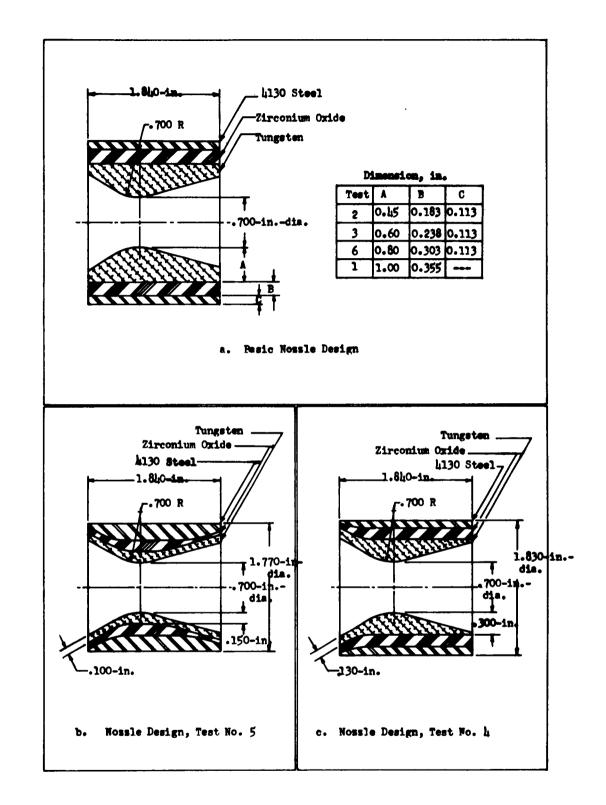


Figure 21: Test Nozzle Designs

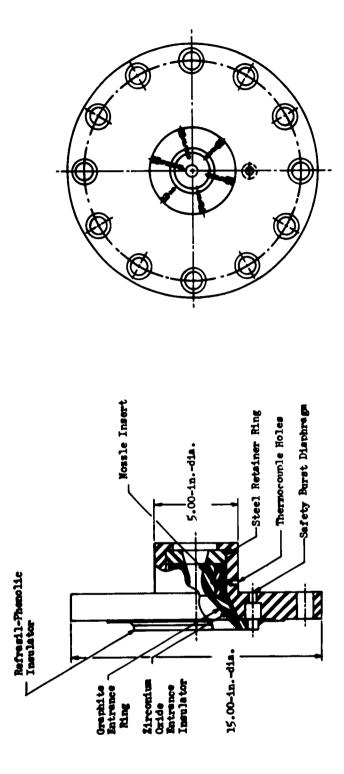


Figure 22: Aft Closure Assembly

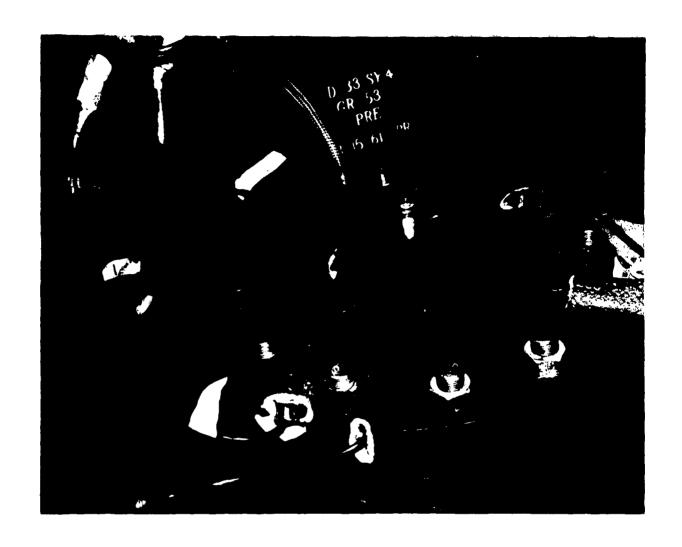
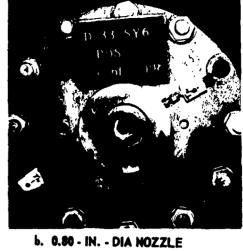


Figure 23: Typical Aft Closure Assembly Before Firing

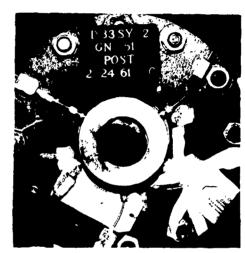


a. 1.00 - IN. - DIA NOZZLE





c. 0.60 - IN. - DIA NOZZLE



d. 0.45 - IN. - DIA NOZZLE

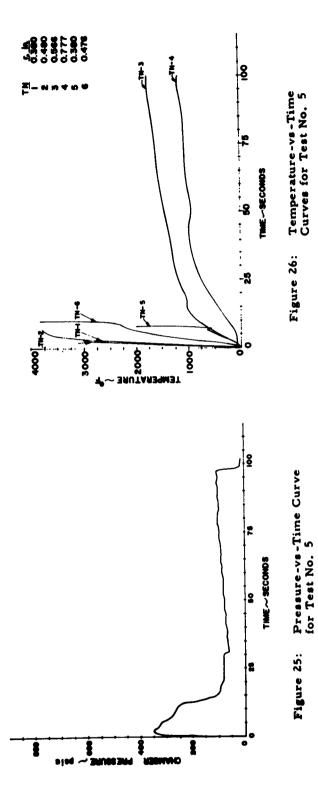


•. 0.30 - IN. - DIA NOZZLE



f. 0.15 - IN. - DIA NOZZLE

Figure 24: Postfiring Photographs of Nozzle Exits



TEST NO. 5

Tungsten Throat Thickness: 0.15 in.
Insulation Thickness: 0.155 in.
Throat Diameter
Before Firing: 0.700 in.

1.00

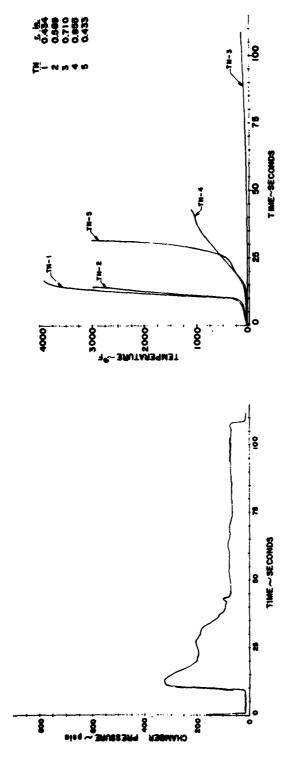


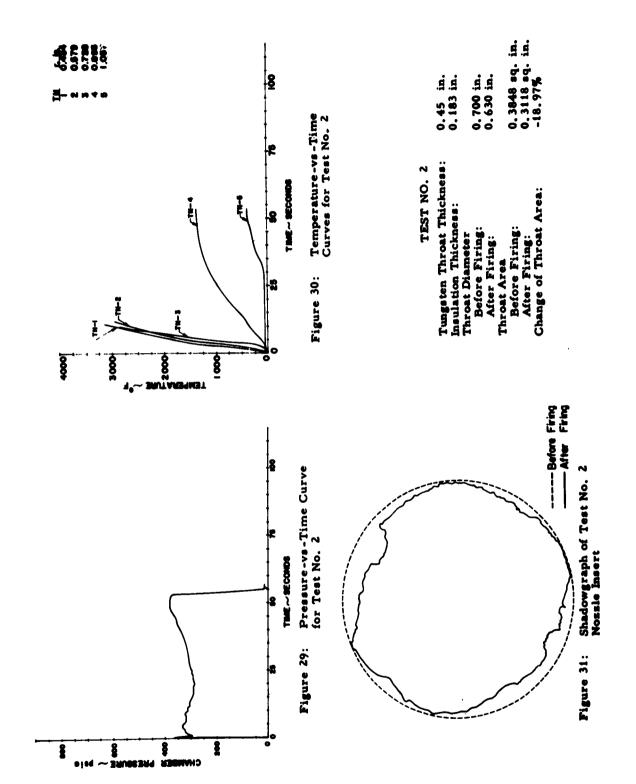
Figure 28: Temperature-vs-Time Curves for Test No. 4

Pressure-vs-Time Curve for Test No. 4

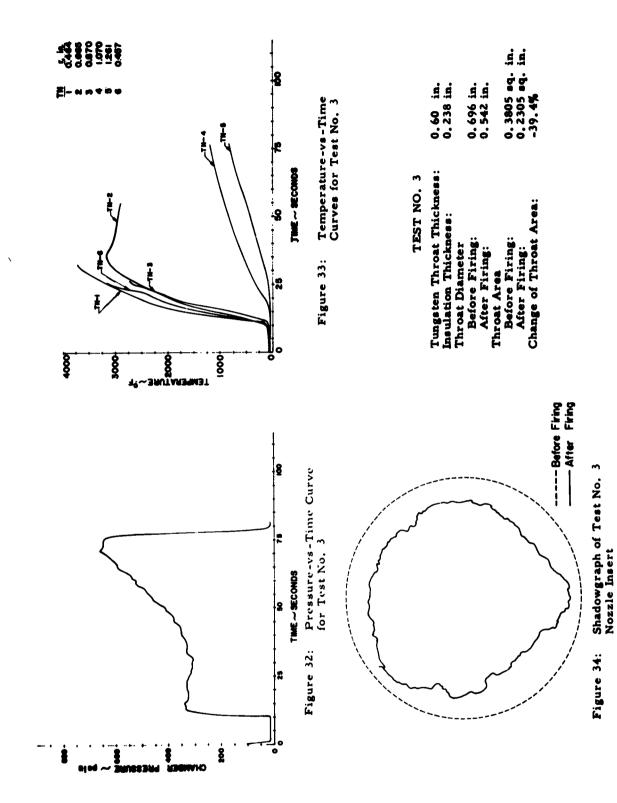
Figure 27:

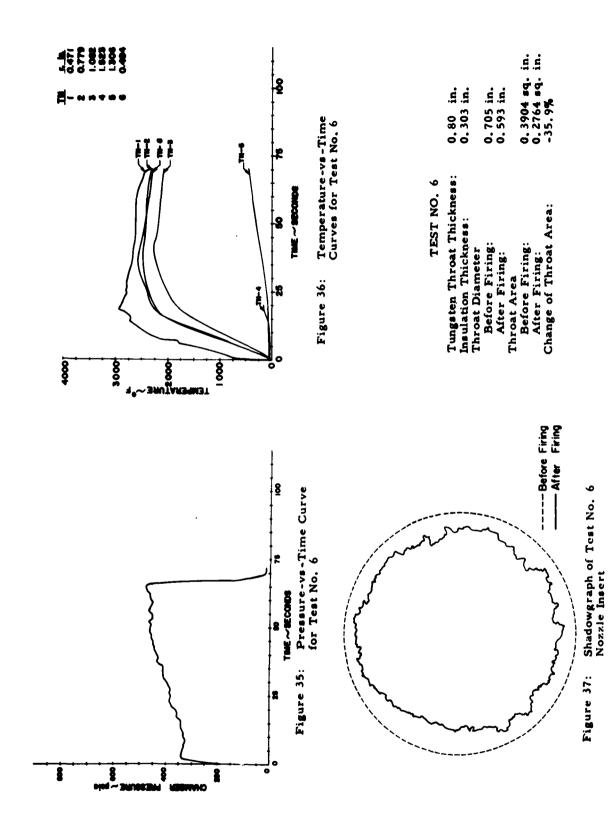
TEST NO. 4
Tungsten Throat Thickness: 0.30 in.
Insulation Thickness: 0.155 in.

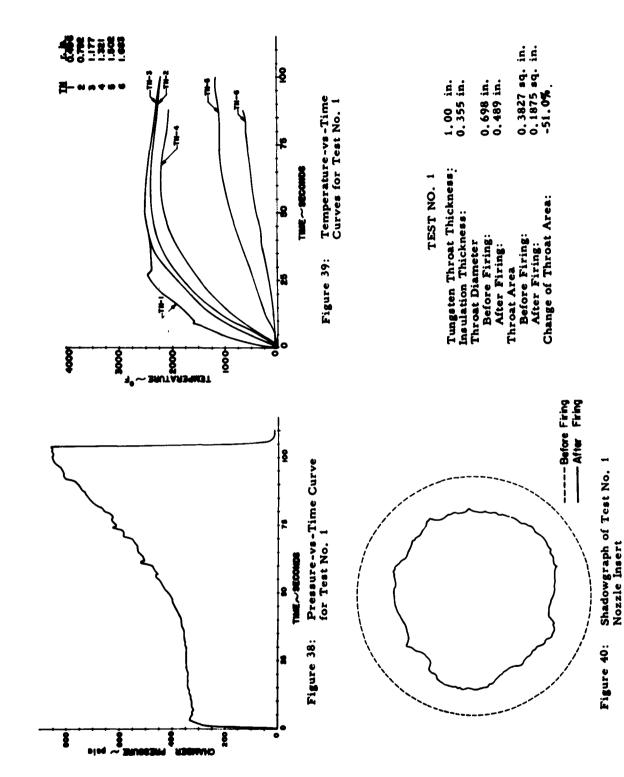
Throat Diameter
Before Firing: 0.700 in.



.







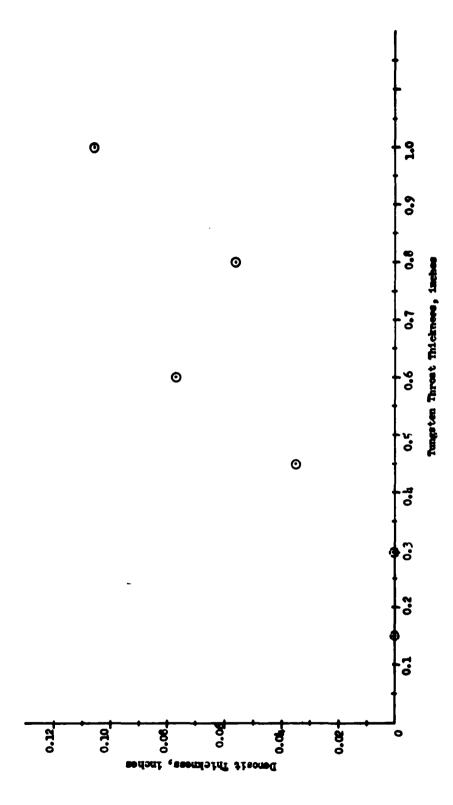


Figure 41: Aluminum Oxide Deposit Thickness as a Function of Tungsten Throat Thickness



Figure 42: Entrance Section of Test No. 2 Nozzle Insert After Firing

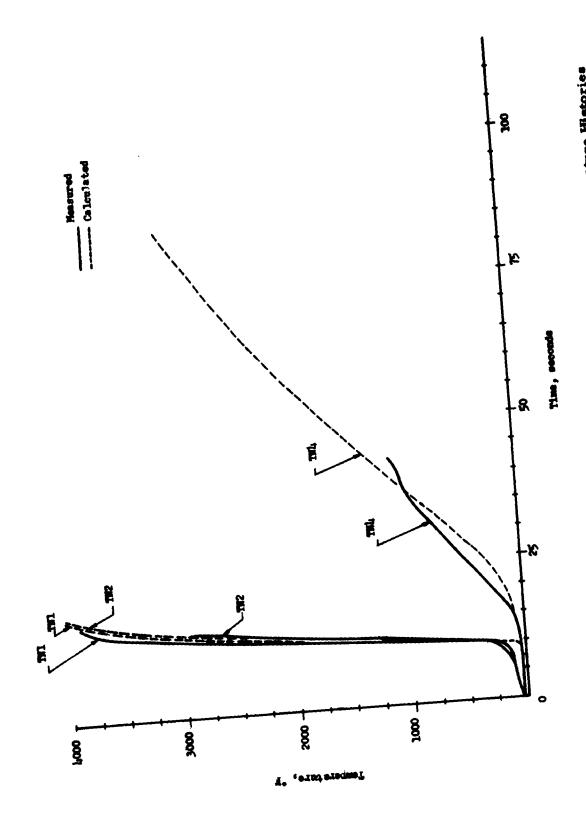


Figure 43: Comparison of Test No. 4 Data with Calculated Temperature Histories

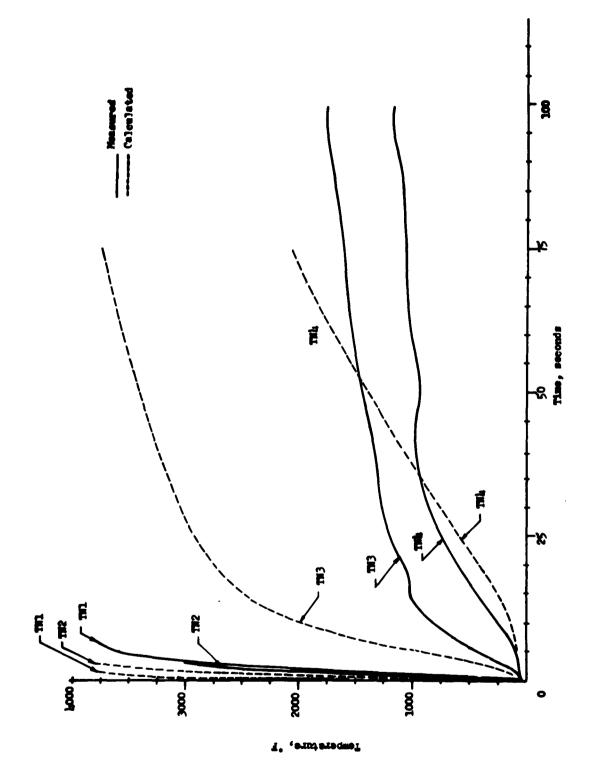


Figure 44: Comparison of Test No. 5 Data with Calculated Temperature Histories

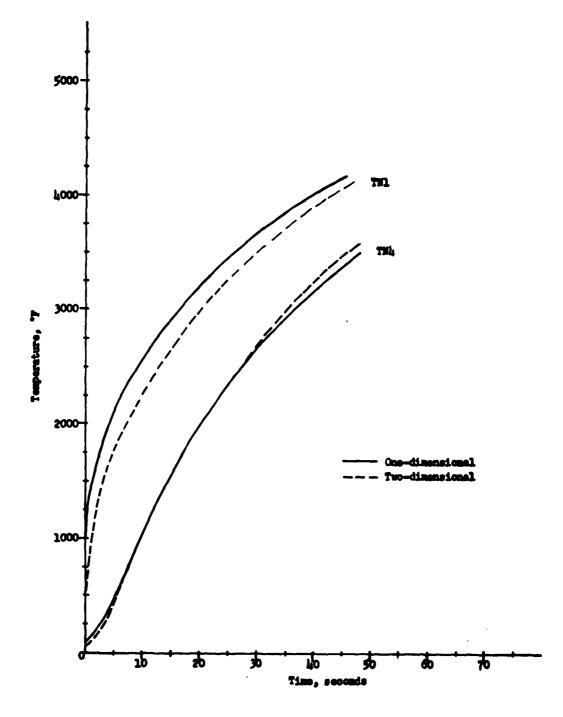


Figure 45: Comparison of Temperatures Based on One- and Two-Dimensional Heat Transfer Calculations for Test Nozzle No. 1

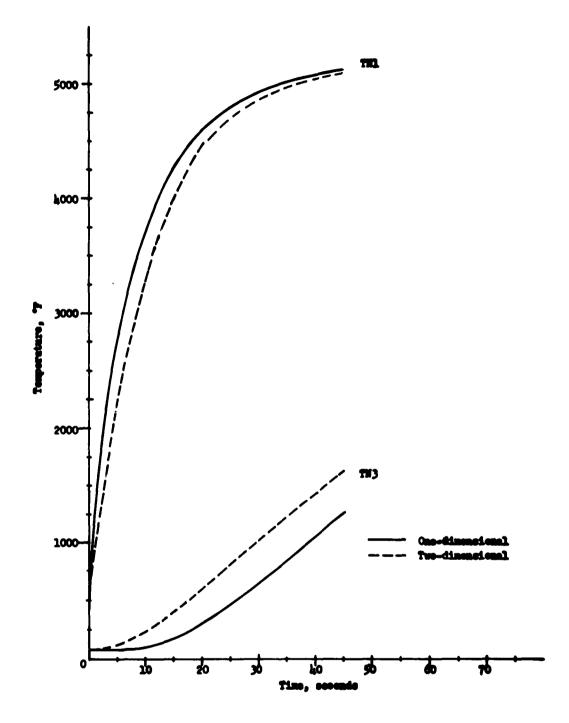


Figure 46: Comparison of Temperatures Based on One- and Two-Dimensional Heat Transfer Calculations for Test Nozzle No. 2

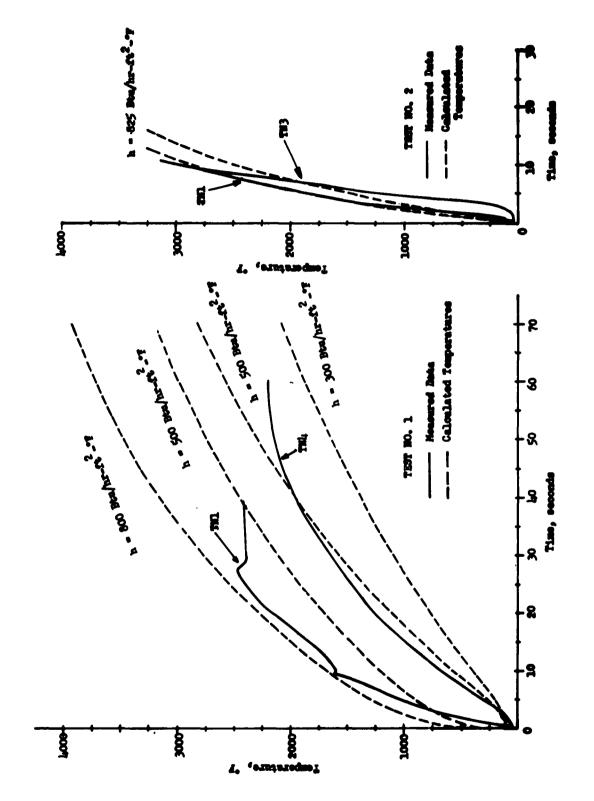


Figure 47: Comparison of Test Data with Calculated Temperature Histories for Various Heat Transfer Coefficients

VII. APPENDIX I

CALCULATION OF HEAT TRANSFER COEFFICIENTS

The equation used to calculate nozzle heat transfer coefficients was based on the equation for turbulent flow in a pipe (Reference 1):

$$\frac{hD}{k} = 0.023 \left(\frac{DG}{\mu}\right)^{0.8} \left(\frac{C_p \mu}{k}\right)^{0.4} \tag{1}$$

Although flow in straight pipes differs considerably from nozzle flow, because of the more fully developed boundary layer in pipe flow, Equation (1) adequately describes the nozzle heat transfer coefficient (References 2, 3).

Considering that

$$G = \frac{4W}{\pi D^2} \tag{2}$$

and

$$W = c_{W} A_{\downarrow} P_{C}$$
 (3)

Equation (1) reduces to

$$h = 0.023 \frac{(c_w P_c)^{0.8} D_T^{1.6}}{D^{1.8}} \cdot \frac{C_p^{0.4} k^{0.6}}{u^{0.4}}$$

In aluminized polygrethane propellants, $c_{\overline{W}}$ usually varies between 22.7 and 24 lbm/lbf-hr. In addition, the transport properties of 10 polymethane propellants with combustion temperatures between 4600 and 5500°F were

examined, and the product $\frac{C_p^{0.4}k^{0.6}}{\mu 0.4}$ was found, for all of the propellants, to be within 5% of the average value (Reference 4). This product was also found to decrease, as shown in Figure 1, in the supersonic portion of the

nozzle. For propellants with higher combustion temperatures, this product of the transport properties will probably be slightly higher, but the difference will not have any significant effect on any but the most precise heat transfer calculations.

Equation (4) then reduces to

$$h = 24.7 \frac{P_c^{0.8} d_t^{1.6}}{d^{1.8}} \cdot \frac{C_p^{0.4} k^{0.6}}{\mu \ 0.4}$$
 (5)

This equation may be used to calculate heat transfer coefficients along the nozzle wall. For calculation of throat heat transfer coefficients, Equation (5) may be further reduced to

$$h = 8.95 \frac{P_c^{0.8}}{d_t^{0.8}}$$
 (6)

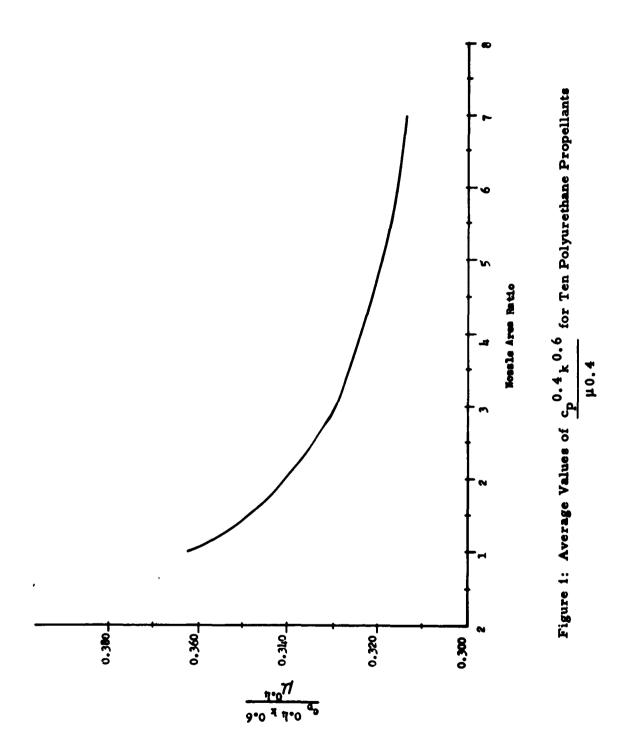
The heat transfer coefficient at the throat is then expressed as a function only of chamber pressure and throat diameter, as is shown in Figure 2.

NOMENCLATURE

- A_t Throat area, in.
- C_n Specific heat, Btu/lb-*F
- c Mass flow coefficient, lbm/lbf-hr
- D Diameter, ft
- D_T Throat diameter, ft
- d Diameter, in.
- d_t Throat diameter, in.
- G Mass flow rate, lb/ft²-hr
- h Heat transfer coefficient, Btu hr-ft²-°F
- k Thermal conductivity, Btu ht-ft-*F
- $\mathbf{P}_{\mathbf{C}}$ Chamber pressure, psi
- W Weight flow, 1bm/hr
- μ Viscosity lbm/ft-hr

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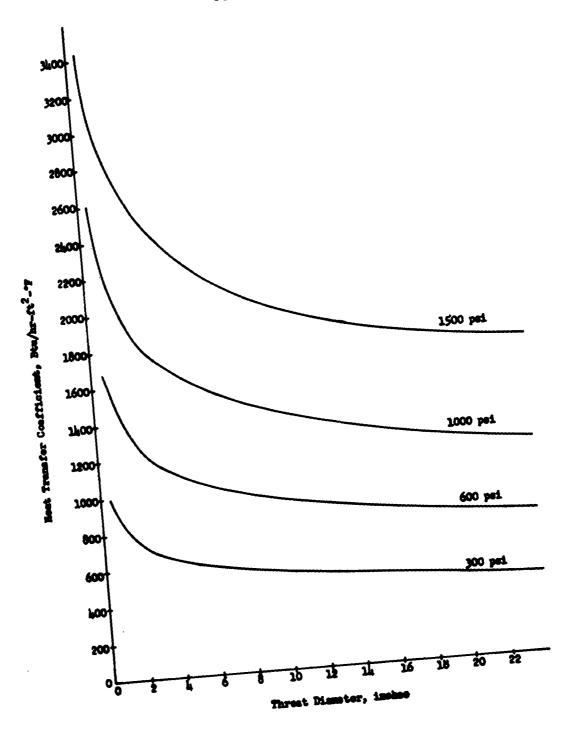


Figure 2: Throat Heat Transfer Coefficient as a Function of Chamber Pressure and Throat Diameter

VIII. APPENDIX II

TABULATION OF IBM OUTPUTS

All the computer runs that resulted in temperature histories of nozzle material systems are tabulated in the following pages. The cases are grouped by the variables which were changed for each run. A pressure change is reflected by a change in heat transfer coefficient. Where one set of temperatures is listed for a case, the time chosen is nearly always the time (usually to the nearest second) at which the maximum allowable flame barrier, heat-sink, or insulator temperature was reached, or, with very long durations, the time the computer was stopped. In some cases, two durations are shown. The other duration represents the time when the maximum allowable flame barrier temperature was reached, even though the limiting insulator temperature was exceeded. For some four-material systems, weights were not calculated because it was decided not to represent these systems on a weight basis.

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| 14 | - 1 | NIERF | ACE TEM | SEBATUR | E BETL | EEN MAT- | AND MAT | -39F • | | | _ |
| 15 | -1 | NTERE | ACE TEM | FRATUR | F RET | IEEN MAT-4 | AND MAT | -4.F. | | | |
| DUI | | | ON . SEC . | CKAION | | ICCH MAI-4 | | -291 4 | | | |
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| | RYLLIU | | | | | •420 | | 173 | | | 4500 |
| | RON CA | | | - | | •500 | | 156 | - | | 4400- |
| | O GRA | | | | | -480 | | 140 | | | 6600 |
| | RO GRA | | | • • | | •480 | | 140 | | | 6600- |
| | ITALUM | | | | | -054 | | 899 | | | 7000 |
| | ranium | | | | | •250 | | 300 | | | 5600- |
| | <u>igsten</u> | | 40, | | | 0353 | | | 70 • 7 • 6 | | <u> </u> |
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| | - | | 00 7000 | | | | | 3116 5 | | 100 | 47.64 |
| | | | 00 7000 | | | | | 3013 2 | | 96 | 47.44- |
| | | | 00 7000 | | | | | 2981 8 | | 16 | 14.61 |
| | | | 00 7000 | | | | | 3010 3 | | 120 | 55.46- |
| | | | 00 7000 | | | | | 3020 1 | | 120 | 55.33 |
| 6- | 1D 4.0 | 00 17 | 00 7000 | 1.650 | 0.110 | 0.250 | | 2986 10 | | 30 | 21.72- |
| | | | 00 7000 | | | | | 2955 1 | | 62 | 32.18 |
| | | | 00 7000 | | | | 6095 | 2289 9 | 31 | 160 | 84.92- |
| 6- | 16 4.0 | 00 17 | 00 7000 | 2.910 | 0.200 | 0.250 | 6031 | 3004 9 | 2 | 90 | 45.50 |
| | | | 00 7000 | | | | 6099 | 2484 1 | 191 | 150 | 75.32- |
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Appendix II

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| 6-3W 18-00 1240 7000 1.500 0.150 0.250 5387 2993 113 24 62-84-84M 18.00 1240 7000 4.500 0.150 0.250 6101 2842 479 115 174-2 6-5W 18-00 1240 7000 3.500 0.250 0.250 6101 2842 479 115 174-2 6-6W 18-00 1240 7000 3.500 0.250 0.250 6101 2842 479 115 174-2 6-6W 18-00 1240 7000 2.750 0.100 0.250 5923 2996 529 69 127-2 6-12 4.733 1218 7000 3.000 0.150 0.250 5816 2998 489 101 52.18 6-5Z 4.733 1218 7000 3.000 0.120 0.250 5816 2998 489 101 52.18 6-5Z 4.733 1218 7000 3.200 0.120 0.250 5883 3007 748 123 59.28 6-12Z4-733 1218 7000 3.200 0.120 0.250 5883 3007 748 123 59.28 6-12Z4-733 1218 7000 3.200 0.120 0.250 5863 3012 712 116 54.28 6-12Z4-733 1218 7000 2.000 0.120 0.250 5863 3012 712 116 54.28 6-12Z4-733 1218 7000 2.000 0.120 0.250 5863 3012 712 116 54.28 6-12Z4-733 1218 7000 2.000 0.120 0.250 5863 3012 712 116 54.28 6-12Z4-733 1218 7000 2.000 0.120 0.250 5863 3012 712 116 54.28 6-12Z4-733 1218 7000 2.000 0.120 0.250 5863 3012 712 116 54.28 6-12Z4-733 1218 7000 2.000 0.120 0.250 5863 3012 712 116 54.28 6-12Z4-733 1218 7000 2.250 0.150 0.250 5151 2995 300 61 59.68 6-12Z4-700 615 7000 2.250 0.150 0.250 5151 2995 300 61 59.68 6-12Z4-700 615 7000 2.250 0.150 0.250 5151 2995 300 61 59.68 6-12Z4-700 615 7000 2.250 0.150 0.250 5152 2995 314 34 500 615 615 7000 2.250 0.150 0.250 5152 2995 314 34 25.48 6-12Z 9.610 304 7000 2.500 0.150 0.250 5440 3008 281 82 2279 6-12Z9.610 304 7000 2.500 0.150 0.250 5440 3008 281 82 2279 6-12Z9.610 304 7000 2.500 0.150 0.250 5440 3008 281 82 2279 6-12Z9.610 304 7000 2.2600 0.150 0.250 540 3008 281 82 2279 6-12Z9.610 304 7000 2.2000 0.150 0.250 540 3008 281 123 68.21 6-12Z9.610 304 7000 2.2000 0.150 0.250 540 3008 281 123 68.21 6-12Z9.610 304 7000 2.2000 0.150 0.250 540 3008 281 123 68.21 123 68.21 6-12Z9.610 304 7000 2.2000 0.150 0.250 500 3008 60 12Z 50 600 0.150 0.250 500 3008 60 12Z 50 600 0.150 0.250 500 3008 60 12Z 50 600 0.150 0.250 500 500 500 500 500 500 500 500 500 | 6-1W 18-00 14 | 240 7000 3.35 240 7000 2.00 | 0 0.200 | 0.250 0.250 | | | | | |
| ### 18.00 1240 7000 4.000 0.150 0.250 | 6-3W 18-00 12 | 240 7000 1.50 | 0 0.150 | 0.250 | | | | | |
| 6-5W 18-00 1240 7000 3-750 0-150 0-250 608 2928 80 184 17-2-6-40 18-00 1240 7000 2-750 0-100 0-250 5923 2996 529 69 127-2-6-7W 18-00 1240 7000 2-750 0-100 0-250 5923 2996 529 69 127-2-6-7W 18-00 1240 7000 2-750 0-100 0-250 5923 2996 529 69 127-2-6-12 4-733 1218 7000 3-200 0-120 0-250 5816 2998 449 101 52-18-6-22 4-733 1218 7000 3-200 0-120 0-250 5863 5012 712 116 54-26-6-12 4-733 1218 7000 3-200 0-120 0-250 5863 5012 712 116 54-26-6-12 4-733 1218 7000 3-200 0-120 0-250 5863 5012 712 116 54-26-6-12 4-700 615 7000 2-000 0-120 0-250 5863 5012 712 116 54-26-6-12 4-700 615 7000 2-000 0-120 0-250 5863 5012 712 116 54-26-6-12 4-700 615 7000 2-000 0-120 0-250 5863 5012 712 116 54-26-6-12 4-700 615 7000 2-750 0-200 0-250 5142 2997 506 107 59-81 6-12 4-700 615 7000 2-800 0-150 0-250 5142 2997 506 107 59-81 6-12 4-700 615 7000 2-800 0-150 0-250 5142 2997 506 107 59-81 6-32 9-610 304 7000 1-000 0-100 0-250 3742 2980 314 42 58-49 6-32 9-610 304 7000 2-200 0-250 0-250 5195 2994 528 112 58-93 6-32 9-610 304 7000 2-200 0-250 0-250 440 3008 281 85 52-79 6-1029-610 304 7000 2-500 0-150 0-250 440 3008 281 85 52-79 6-1029-610 304 7000 2-500 0-150 0-250 440 3008 281 85 52-79 6-1029-610 304 7000 2-500 0-150 0-250 440 3008 281 85 52-79 6-129-610 304 7000 2-500 0-150 0-250 3444 3009 330 34 23-49 6-82 11-88 205 7000 0-750 0-100 0-250 3444 3009 330 34 23-49 6-91 11-88 205 7000 1-500 0-150 0-250 3444 3009 330 34 23-49 70 11-88 205 7000 1-500 0-150 0-250 3444 3009 330 34 23-49 70 11-88 205 7000 1-500 0-150 0-250 3444 3009 330 34 23-49 70 11-88 205 7000 1-500 0-150 0-250 3444 3009 330 34 23-49 70 11-88 205 7000 1-500 0-250 3444 3009 330 34 23-49 70 11-88 205 7000 1-500 0-150 0-250 3444 3009 330 34 23-49 70 11-88 205 7000 1-500 0-150 0-250 3444 3009 330 34 23-49 70 11-88 205 7000 1-500 0-150 0-250 3444 3009 330 34 23-49 70 11-88 205 7000 1-500 0-150 0-250 3444 3009 330 34 23-49 70 11-88 205 7000 1-500 0-5 | | | | | | | | | |
| 6-TW 18.00 1240 7000 2.750 0.100 0.250 5923 2996 529 69 127.2 - 6-12 4.733 1218 7000 3.000 0.120 0.250 5818 2000 7459 123 592.8 6-1224.733 1218 7000 3.200 0.120 0.250 5818 3007 749 123 592.8 6-1224.733 1218 7000 3.200 0.120 0.250 5865 3012 712 116 54.26 6-1224.733 1218 7000 3.200 0.120 0.250 5865 3012 712 116 54.26 6-1224.733 1218 7000 2.200 0.120 0.250 5865 3012 712 116 54.26 6-124.733 1218 7000 2.200 0.120 0.250 5865 3012 712 116 54.26 6-124.733 1218 7000 2.200 0.120 0.250 5867 3012 712 116 54.26 6-124.733 1218 7000 2.200 0.120 0.250 5805 3012 712 116 54.26 6-124.730 615 7000 2.800 0.150 0.250 5150 5892 3014 103 58.62 6-124.700 615 7000 2.750 0.200 0.150 0.250 5174 2997 506 107 59.61 6-124.700 615 7000 2.800 0.150 0.250 5174 2997 506 107 59.61 6-124.700 615 7000 2.800 0.150 0.250 5174 2997 506 107 59.61 6-124.700 615 7000 2.800 0.150 0.250 5174 2997 506 107 59.61 6-124.700 615 7000 2.800 0.150 0.250 5174 2997 506 107 59.61 6-124.700 615 7000 2.800 0.150 0.250 5174 2997 506 107 59.61 6-124.700 615 7000 2.800 0.150 0.250 5174 2997 508 112 58.93 512 58.93 512 59.61 304 7000 2.800 0.150 0.250 4260 3008 281 88 52.79 6-1229.610 304 7000 2.800 0.150 0.250 4260 3008 281 88 52.79 6-1229.610 304 7000 2.800 0.150 0.250 4260 3008 281 88 52.79 6-1229.610 304 7000 2.800 0.150 0.250 4419 2996 604 123 68.21 6-1229.610 304 7000 2.800 0.150 0.250 3446 3009 330 34 23.69 6-1229.610 304 7000 2.800 0.150 0.250 3446 3009 330 34 23.69 7 6-1229.610 304 7000 2.800 0.150 0.250 3446 3009 330 34 23.69 7 6-1229.610 304 7000 2.800 0.050 0.050 0.250 3464 3009 330 34 23.69 7 7 8 46.72 7 8 4 | 6-5W 18.00 12 | 240 7000 3.75 | 0 0.150 | 0.250 | 6101 | 2042 | 479 | 115 | 174.2 |
| 6-12 4.733 1218 7000 3.000 0.150 0.250 5816 2998 449 101 52.18-6-57 4.733 1218 7000 3.200 0.120 0.250 5883 3007 749 123 59.28 6-1224.733 1218 7000 3.200 0.120 0.250 5863 3012 712 116 54.26 6-1224.733 1218 7000 3.200 0.120 0.250 5863 3012 712 116 54.26 6-1224.733 1218 7000 3.200 0.120 0.250 5867 3008 653 117 54.16 6-22 6.700 615 7000 2.000 0.120 0.250 4892 3023 402 61 39.76 6-62 6.700 615 7000 2.000 0.120 0.250 4892 3023 402 61 39.76 6-62 6.700 615 7000 2.8750 0.200 0.250 5174 2997 506 107 59.61 6-62 6.700 615 7000 2.875 0.150 0.250 5174 2997 506 107 59.61 6-1224.700 615 7000 2.875 0.150 0.250 5174 2997 506 107 59.61 6-1224.700 615 7000 2.875 0.150 0.250 5174 2997 506 107 59.61 6-1224.700 615 7000 2.875 0.150 0.250 5174 2997 506 107 59.61 6-1224.700 615 7000 2.875 0.150 0.250 5174 2997 506 107 59.61 6-1224.700 615 7000 2.870 0.150 0.250 5174 2997 506 107 59.61 6-1224.700 615 7000 2.000 0.200 0.250 3742 2990 314 34 25.40 6-727.9610 304 7000 2.000 0.200 0.250 3742 2990 314 34 25.40 6-727.9610 304 7000 2.000 0.250 0.250 3742 2990 314 34 25.40 6-727.9610 304 7000 2.500 0.150 0.250 3742 2990 314 34 25.40 6-727.168 205 7000 2.000 0.250 3.250 3446 3008 281 88 52.79 6-1029.610 304 7000 2.500 0.150 0.250 3446 3008 281 88 52.79 6-1029.610 304 7000 2.500 0.150 0.250 3446 3009 330 34 23.49 6-72 11.68 205 7000 2.000 0.150 0.250 3446 3009 330 34 23.49 6-72 11.68 205 7000 2.000 0.150 0.250 3446 3009 330 34 23.49 6-72 11.68 205 7000 2.000 0.150 0.250 3949 3009 593 115 63.18 6-127 11.68 205 7000 2.000 0.150 0.250 3948 3008 221 121 61.200 1100 6-127 11.68 205 7000 2.000 0.150 0.250 3948 3009 593 115 63.18 6-127 11.68 205 7000 2.000 0.150 0.250 3948 3009 593 115 63.18 6-127 11.68 205 7000 2.000 0.150 0.250 3948 3009 593 115 63.18 6-127 11.68 205 7000 2.000 0.150 0.250 3948 3009 593 115 63.18 6-127 11.000 0. | 6-6W 18-00 1 | 240 7000 3.50 | 0 0.280 | 0.250 | | | | | |
| 4-32 4-733 1218 7000 3-300 0-120 0-250 5865 3002 712 116 94-26-6-1324-733 1218 7000 3-220 0-130 0-250 5865 3012 712 116 94-26-6-1324-733 1218 7000 3-220 0-130 0-250 5865 3012 712 116 94-26-6-1324-733 1218 7000 3-220 0-130 0-250 5867 3008 653 117 54-76-6-26 6-1324-700 615 7000 2-3700 0-250 0-250 5867 3008 653 117 54-76-6-26 8-700 615 7000 2-3700 0-250 0-250 5153 7292 314 103 58662 6-1126-700 615 7000 2-870 0-250 0-250 5153 7292 314 103 58662 6-1126-700 615 7000 2-875 0-150 0-250 5174 2997 506 107 59-81-6-126-700 615 7000 2-875 0-150 0-250 5175 2994 528 112 58693 6-32 9-610 304 7000 1-000 0-100 0-250 3742 2990 314 34 25-64-6-22 9-610 304 7000 2-000 0-200 0-250 3742 2990 314 34 25-64-6-72 9-610 304 7000 2-500 0-150 0-250 4290 3008 261 88 52-79 6-1029-610 304 7000 2-500 0-150 0-250 4419 2996 604 123 66-21-6-1229-610 304 7000 2-500 0-150 0-250 4419 2996 604 123 66-21-6-1229-610 304 7000 2-500 0-150 0-250 4419 2996 604 123 66-21-6-1229-610 304 7000 2-500 0-150 0-250 3446 3009 330 34 23-49-6-82 11-88 205 7000 0-150 0-250 3446 3009 330 34 23-49-6-82 11-88 205 7000 0-150 0-250 3446 3009 330 34 23-49-6-82 11-88 205 7000 0-150 0-250 3045 3009 350 34 23-49-6-92 11-88 205 7000 0-150 0-250 3949 3009 593 115 63-18-6-92 11-88 205 7000 0-150 0-250 3949 3009 593 115 63-18-6-92 11-88 205 7000 2-000 0-150 0-250 3949 3009 593 115 63-18-6-92 11-88 205 7000 2-000 0-150 0-250 3949 3009 593 115 63-18-6-92 11-88 205 7000 2-000 0-150 0-250 3949 3009 593 115 63-18-6-92 11-88 200 1700 7000 3-800 0-000 0-250 4000 4000 821 121 61-90 1700 3-800 0-000 0-250 4000 4000 4000 4000 4000 4000 4000 4 | 6-7W 18.00 12 | 240 7000 2.75 | 0 0.100 | 0.250 | 5923 | 2796 | 529 | 69 | 127.2 - |
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| 6-16ZIL-88 204 7000 2a070 0a150 0a250 3968 3008 621 121 61a90 TUNGSTEN-ASBESTOS-TITANIUM 6-2Y 4a000 1700 7000 3a600 0a090 0a250 6099 2779 1037 129 59a89 TUNGSTEN-ASBESTOS-TUNGSTEN 6-3Y 4a000 1700 7000 3a000 0a075 0a250 6098 3006 1143 98 50a35 TUNGSTEN-ATJ GRAPHITE-TUNGSTEN 6-3Y 4a000 1700 7000 1a000 2a000 0a250 6101 4448 2822 109 19a09 TUNGSTEN-ASBESTOS-6130 STEEL 10-A 4a000 1700 7000 1a000 2a000 0a250 6116 3868 83 13 11a50 10-A 4a000 1700 7000 0a00 0a940 0a162 0a250 6116 3868 83 13 11a50 10-B 4a000 1700 7000 2a222 0a158 0a250 6104 93814 403 72 31a68 11-A 4a000 1700 7000 1a125 0a154 0a250 6106 4970 89 6a75 6a26 11-B 4a000 1700 7000 1a125 0a154 0a250 6106 4970 89 6a75 6a26 11-B 4a000 1700 7000 1a125 0a154 0a250 6106 4970 89 6a75 6a26 11-B 4a000 1700 7000 1a125 0a154 0a250 6100 2481 138 9 12a60 12-A 4a000 2350 8000 1a035 0a067 0a250 5560 3090 86 8 10a14 21-A 4a000 2350 8000 0a632 0a049 0a250 5560 3090 86 8 10a14 22-A 4a000 2350 8000 1a035 0a067 0a250 5560 3090 86 8 10a14 22-A 4a000 650 6500 3a500 0a100 0a250 5561 2771 122 4 7a53 22-A 4a000 650 6500 3a500 0a100 0a250 5013 2980 1348 200 58660 22-C 4a000 650 6500 3a500 0a100 0a250 5013 2980 1348 200 58660 22-C 4a000 650 6500 0a680 0a353 0a250 4441 3020 234 46 19a77 22-A 4a000 650 6500 0a680 0a353 0a250 4332 924 125 290 16109 23-A 24a00 1670 8000 1a289 0a501 0a250 5013 2980 1348 200 58660 100 23-A 4a000 1700 7000 3a350 0a194 0a250 6138 2918 80 14 78a20 23-A 4a000 1700 7000 3a350 0a194 0a250 6094 3001 170 103 55a31 10-A 4a000 1700 7000 3a350 0a194 0a250 6094 3001 170 103 55a31 10-A 4a000 1700 7000 3a350 0a194 0a250 6094 3001 170 103 55a31 10-A 4a000 1700 7000 3a350 0a194 0a250 6094 2996 207 115 55a87 100651EN-ASBESTOS(K=1a500-C=0a116)-4130 STEEL 3-A 4a000 1700 7000 3a350 0a194 0a250 6094 2996 207 115 55a87 100651EN-ASBESTOS(K=1a500-C=0a116)-4130 STEEL 3-A 4a000 1700 7000 3a350 0a194 0a250 6094 2996 207 115 55a87 100651EN-ASBESTOS(K=1a500-C=0a116)-4130 STEEL 3-A 4a000 1700 7000 3a350 0a972 0a250 6094 2996 207 115 55a87 100651EN-ASBESTOS(K=1a500-C=0a116)-4130 STEEL 3-A | | | | | | | | | |
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| 21-A 4.000 2350 8000 1.035 0.067 0.250 6100 2481 138 9 12.60 21-B 4.000 2350 8000 0.632 0.049 0.250 5541 2771 122 4 7.53 - 22-A 4.000 650 6500 1.522 0.146 0.250 4441 3020 234 46 19.77 22-B 4.000 650 6500 3.500 0.100 0.250 5013 2980 1348 200 58.60 22-C 4.000 650 6500 0.420 0.053 0.250 3771 3187 220 8 6.42 23-C 4.000 650 6000 6.808 0.353 0.250 4332 924 125 250 161.9- 23-A 24.00 1670 8000 1.289 0.501 0.250 6138 2918 80 14 78.20 23-B 4.000 2390 8000 1.015 0.065 0.250 6118 2737 139 8.75 12.33- TUNGSTEN-ASBESTOS(K=0.060,C=0.116)-4130 STEEL 1-A 4.000 1700 7000 3.350 0.194 0.250 6094 3001 170 103 55.31- 2-A 4.000 1700 7000 1.650 0.048 0.250 6095 2999 665 114 21.60 TUNGSTEN-ASBESTOS(K=1.500.C=0.116)-4130 STEEL 3-A 4.000 1700 7000 3.350 0.402 0.250 6094 2996 207 115 55.87 TUNGSTEN-ASBESTOS(K=1.500.C=0.116)-4130 STEEL 4-A 4.000 1700 7000 3.350 0.972 0.250 6094 2996 207 125 55.87 | 11-B 4.000 1 | 700 7000 1.12 | 5 0.114 | 0.250 | 6115 | 4806 | 346 | 2.2 | 13.90 |
| 21-8 4.000 2350 8000 0.632 0.049 0.250 5541 2771 122 4 7.53 - 22-A 4.000 650 6500 1.522 0.146 0.250 4441 3020 234 46 19.77 22-8 4.000 650 6500 3.500 0.100 0.250 5013 2980 1348 200 58.60 - 22-C 4.000 650 6500 0.420 0.053 0.250 3771 3187 220 8 6.42 - 23-C 4.000 650 6000 6.808 0.353 0.250 4332 924 125 250 161.9 - 23-A 24.00 1670 8000 1.289 0.501 0.250 6138 2918 80 14 78.20 - 23-B 4.000 2390 8000 1.015 0.065 0.250 6118 2737 139 8.75 12.33 - TUNGSTEN-ASBESTOS(K=0.060,C=0.116)-4130 STEEL - 1-A 4.000 1700 7000 3.350 0.194 0.250 6094 3001 170 103 55.31 - 2-A 4.000 1700 7000 1.650 0.048 0.250 6095 2999 665 114 21.60 - TUNGSTEN-ASBESTOS(K=1.500,C=0.116)-4130 STEEL - 3-A 4.000 1700 7000 3.350 0.402 0.250 6094 2996 207 115 55.87 - TUNGSTEN-ASBESTOS(K=1.500,C=0.116)-4130 STEEL - 4-A 4.000 1700 7000 3.350 0.972 0.250 6114 2989 361 123 57.47 - 4-B 4.000 1700 7000 1.650 0.486 0.250 5664 2988 254 31 22.47 | | | | | | | | - | 10.14 |
| 22-A 4.000 650 6500 1.522 0.146 0.250 4441 3020 234 46 19a77 22-B 4.000 650 6500 3.500 0.100 0.250 5013 2980 1348 200 58.60- 22-C 4.000 650 6500 0.420 0.053 0.250 3771 3187 220 8 6.42 23-C 4.000 650 6000 6.808 0.353 0.250 4332 924 125 250 161.9- 23-A 24.00 1670 8000 1.289 0.501 0.250 6138 2918 80 14 78.20 23-B 4.000 2390 8000 1.015 0.065 0.250 6118 2737 139 8.75 12.33- TUNGSTEN-ASBESTOS(K=0.060,C=0.116)-4130 STEEL 1-A 4.000 1700 7000 3.350 0.194 0.250 6094 3001 170 103 55.31- 2-A 4.000 1700 7000 1.650 0.048 0.250 6085 2999 665 114 21.60 TUNGSTEN-ASBESTOS(C=0.116)-4130 STEEL 3-A 4.000 1700 7000 3.350 0.480 0.250 6094 2996 207 115 55.87 TUNGSTEN-ASBESTOS(K=1.500,C=0.116)-4130 STEEL 4-A 4.000 1700 7000 3.350 0.972 0.250 6114 2989 361 123 57.47 4-B 4.000 1700 7000 3.350 0.972 0.250 6114 2989 361 123 57.47 | 21-A 4-000 Z | <u>350 8000 1.03</u> | 5 0.067 | 0.250 | | | | | |
| 22-8 4.000 650 6500 3.500 0.100 0.250 5013 2980 1348 200 58.60-22-C 4.000 650 6500 0.420 0.053 0.250 3771 3187 220 8 6.42 23-C 4.000 650 6000 6.808 0.353 0.250 4332 924 125 250 161.9-25-A 24.00 1670 8000 1.289 0.501 0.250 6138 2918 80 14 78.20 23-8 4.000 2390 8000 1.015 0.065 0.250 6118 2737 139 8.75 12.33-TUNGSTEN-ASBESTOS(K=0.060,C=0.116)-4130 STEEL 1-A 4.000 1700 7000 3.350 0.194 0.250 6094 3001 170 103 55.31-2-A 4.000 1700 7000 1.650 0.068 0.250 6085 2999 665 114 21.60 TUNGSTEN-ASBESTOS(C=0.116)-4130 STEEL 3-A 4.000 1700 7000 3.350 0.402 0.250 6094 2996 207 115 55.87 TUNGSTEN-ASBESTOS(K=1.500,C=0.116)-4130 STEEL 4-A 4.000 1700 7000 3.350 0.972 0.250 6114 2989 361 123 57.47 4-8 4.000 1700 7000 3.350 0.972 0.250 6114 2989 361 123 57.47 | | | | | | | | | |
| 22-C 4.000 650 4500 0.420 0.053 0.250 3771 3187 220 8 4.42 23-C 4.000 650 6000 6.808 0.353 0.250 4332 924 125 250 161.9- 23-A 24.00 1670 8000 1.289 0.501 0.250 6138 2918 80 14 78.20 23-B 4.000 2390 8000 1.015 0.065 0.250 6118 2737 139 8.75 12.33- TUNGSTEN-ASBESTOS(K=0.060,C=0.116)-4130 STEEL 1-A 4.000 1700 7000 3.350 0.194 0.250 6094 3001 170 103 55.31- 2-A 4.000 1700 7000 1.650 0.048 0.250 6085 2999 665 114 21.60 TUNGSTEN-ASBESTOS(C=0.116)-4130 STEEL 3-A 4.000 1700 7000 3.350 0.402 0.250 6094 2996 207 115 55.87 TUNGSTEN-ASBESTOS(K=1.500,C=0.116)-4130 STEEL 4-A 4.000 1700 7000 3.350 0.972 0.250 6114 2989 361 123 57.47 4-B 4.000 1700 7000 1.650 0.486 0.250 5664 2988 254 31 22.47 | | | | | | | | | |
| 23-C 4.000 650 6000 6.808 0.353 0.250 4332 924 125 250 161.9- 23-A 24.00 1670 8000 1.289 0.501 0.250 6138 2918 80 14 78.20 23-B 4.000 2390 8000 1.015 0.065 0.250 6118 2737 139 8.75 12.33- TUNGSTEN-ASBESTOS(K=0.060,C=0.16)-4130 STEEL 1-A 4.000 1700 7000 3.350 0.194 0.250 6094 3001 170 103 55.31- 2-A 4.000 1700 7000 1.650 0.048 0.250 6095 2999 665 114 21.60 TUNGSTEN-ASBESTOS(C=0.116)-4130 STEEL 3-A 4.000 1700 7000 3.350 0.402 0.250 6094 2996 207 115 55.87 TUNGSTEN-ASBESTOS(K=1.500,C=0.116)-4130 STEEL 4-A 4.000 1700 7000 3.350 0.972 0.250 6114 2989 361 123 57.47 4-B 4.000 1700 7000 1.650 0.486 0.250 5664 2988 254 31 22.47 | | | | | | | 7 | | |
| 23-A 24-QQ 1670 8000 1-289 Q-501 Q-250 6138 2918 80 14 78-20 23-B 4-000 2390 8000 1-015 0-065 0-250 6118 2737 139 8-75 12-33- TUNGSTEN-ASBESTOS(K=0.060,C=0.16)-4130 STEEL 1-A 4-000 1700 7000 3-350 0-194 0-250 6094 3001 170 103 55-31- 2-A 4-000 1700 7000 1-650 0-048 0-250 6095 2999 665 114 21-60 TUNGSTEN-ASBESTOS(C=0-116)-4130 STEEL 3-A 4-000 1700 7000 3-350 0-402 0-250 6094 2996 207 115 55-87 TUNGSTEN-ASBESTOS(K=1.500,C=0-116)-4130 STEEL 4-A 4-000 1700 7000 3-350 0-972 0-250 6114 2989 361 123 57-47 4-B 4-000 1700 7000 1-650 0-486 0-250 5664 2988 254 31 22-47 | | | | | | | | | |
| 23-B 4.000 2390 8000 1.015 0.065 0.250 6118 2737 139 8.75 12.33- TUNGSTEN-ASBESTOS(K=0.060,C=0.116)-4130 STEEL 1-A 4.000 1700 7000 3.350 0.194 0.250 6094 3001 170 103 55.31- 2-A 4.000 1700 7000 1.650 0.048 0.250 6085 2999 665 114 21.60 TUNGSTEN-ASBESTOS(C=0.116)-4130 STEEL 3-A 4.000 1700 7000 3.350 0.402 0.250 6094 2996 207 115 55.87 TUNGSTEN-ASBESTOS(K=1.500.C=0.116)-4130 STEEL 4-A 4.000 1700 7000 3.350 0.972 0.250 6114 2989 361 123 57.47 4-B 4.000 1700 7000 1.650 0.486 0.250 5664 2988 254 31 22.47 | 23-A 24-00 1 | 670 8000 1.28 | 9 0.501 | 0.250 | | | | | |
| TUNGSTEN-ASBESTOS(K=0.060,C=0.116)-4130 STEEL 1-A 4.000 1700 7000 3.350 0.194 0.250 6094 3001 170 103 95.31- 2-A 4.000 1700 7000 1.650 0.048 0.250 6085 2999 665 114 21.60 TUNGSTEN-ASBESTOS(K=0.116)-4130 STEEL 3-A 4.000 1700 7000 3.350 0.402 0.250 6094 2996 207 115 55.87 TUNGSTEN-ASBESTOS(K=1.500.C=0.116)-4130 STEEL 4-A 4.000 1700 7000 3.350 0.972 0.250 6114 2989 361 123 57.47 4-B 4.000 1700 7000 1.650 0.486 0.250 5664 2988 254 31 22.47 | 23-8 4-000 2 | 390 8000 1.01 | 5 0.065 | 0.250 | | | | | |
| 2-A 4.000 1700 7000 1.650 0.048 0.250 6085 2999 665 114 21.60 TUNGSTEN-ASBESTOS(C=0.116)-4130 STEEL 3-A 4.000 1700 7000 3.350 0.402 0.250 6094 2996 207 115 55.87 TUNGSTEN-ASBESTOS(K=1.500.C=0.116)-4130 STEEL 4-A 4.000 1700 7000 3.350 0.972 0.250 6114 2989 361 123 57.47 4-B 4.000 1700 7000 1.650 0.486 0.250 5664 2988 254 31 22.47 | TUNGSTEN-ASB | <u> Estos(K=0.060</u> | ·C=0.116 | 1-4130 S | EEL | | | | |
| TUNGSTEN-ASBESTOS(C=0.116)-4130 STEEL 3-A 4.000 1700 7000 3.350 0.402 0.250 6094 2996 207 115 55.87 TUNGSTEN-ASBESTOS(K=1.500.C=0.116)-4130 STEEL 4-A 4.000 1700 7000 3.350 0.972 0.250 6114 2989 361 123 57.47 4-B 4.000 1700 7000 1.650 0.486 0.250 5664 2988 254 31 22.47 | | | | | | | | | |
| 3-A 4.000 1700 7000 3.350 0.402 0.250 6094 2996 207 115 55.87 TUNGSTEN-ASBESTOS(K=1.500.C=0.116)-4130 STEEL 4-A 4.000 1700 7000 3.350 0.972 0.250 6114 2989 361 123 57.47 4-B 4.000 1700 7000 1.650 0.486 0.250 5664 2988 254 31 22.47 | | | | | 60.85 | 2999 | 665 | 114 | 21.0.60 . |
| TUNGSTEN-ASBESTOS(K=1.500.C=0.116)-4130 STEEL 4-A 4.000 1700 7000 3.350 0.972 0.250 6114 2989 361 123 57.47 4-B 4.000 1700 7000 1.650 0.486 0.250 5664 2988 254 31 22.47 | | | | | | 2024 | 207 | | |
| 4-A 4.000 1700 7000 3.350 0.972 0.250 6114 2989 361 123 57.47 4-B 4.000 1700 7000 1.650 0.486 0.250 5664 2988 254 31 22.47 | TIMECTEM-ACR | <u> 190 /990 3.32</u> Estosik=1-600 | <u>v.ya9y6</u> • C=0 - 114 | U9.47U | TEEL | . &YY.O. | .4.V.(: | | 7.7.4.5 1 |
| 4-8 4-000 1700 7000 1-650 0-486 0-250 5664 2988 254 31 22-47 | | | | | | 2949 | 361 | 123 | 57.47 |
| | | | | | | | | | |
| 4-C 44000 1000 24230 DANYS U4230 2867 3001 283 28 33491 | | | | | | | | - 54 | 33.41 |

| 4-D 4.000 1700 7000 2.910 0 | | 6042 2994 | 316 | 88 | 47,15 |
|--|-------------------|--|--------------|-----------------|----------------|
| TUNGSTEN-ASBESTOS (K#1.500)-A | | <u> </u> | 100 | 100 | ** |
| 5-A 4.000 1700 7000 3.350 0 5-B 4.000 1700 7000 1.650 0 | | 6140 2993 5 684 2933 | 7 1 7 | 135 | 56.22 |
| 5-C 4.000 1700 7000 2.250 0 | | 5918 2995 | | 61 | 22.04 32.72 |
| 5-D 4-000 1700 7000 2-230 0 | | 6066 2982 | | 101 | 44.18 |
| TUNGSTEN (K = 10.0)-ASBEST | | | | | |
| 20-8 4-000 1700 7000 0-437 0 | 0067 0.250 | 6109 2636 | 141 | 9 | 5.36 |
| 20-E 4.000 1700 7000 1.165 0 | | 6105 1623 | | 11 | 14.61 |
| 17-F 4.000 1700 7000 2.250 0 | | 6108 80 | 80 | 10 | 32.18 |
| 17-M 4.000 1700 7000 2.250 0 | | 6104 80 | 80 | 20 | 32.18 |
| TUNGSTEN(K=20.)-ASBESTOS-413 | | | | | |
| 20-M 4.000 1700 7600 1.165 0 | | 6102 2046 | | 25 | 14.43 |
| 17-H 4-000 1700 7000 2-250 0 | | 6097 2819 | <u> </u> | 24 | 32.18 |
| TUNGSTEN(K=25.)-ASBESTOS-413 | O STEEL | | | | |
| 20-L 4-000 1700 7000 1-165 0 | 100 0.250 | 6093 2787 | 12 | 28 | 16,43 |
| TUNGSTEN (K = 30.0)-ASBEST | | | | | 10 04 |
| 20-A 4-000 1700 7000 1-471 0 20-F 4-000 1700 7000 1-165 0 | 200 0.280 | <u>4103 2729</u> 5998 29 8 3 | | 37 26 | 18.94 14.61 |
| 17-D 4-000 1700 7000 2-250 0 | | 6104 1536 | | 51 | 32.14 |
| TUNGSTEN(K=50.)-ASBESTOS-413 | O STEEL | 144.4 | | | |
| 20-0 4-000 1700 7000 1-165 0 | | 5542 2986 | 83 | 18 | 14.61 |
| 17-E 4.000 1700 7000 2.250 0 | | 6020 2988 | | 62 | 32.18 |
| TUNGSTEN(K=80.)-ASBESTOS-413 | | | | | |
| 20-K 4.000 1700 7000 1.165 0 | -100 0-250 | 5095 3065 | 132 | 14 | 14.43 |
| 17-J 4.000 1700 7000 2.250 0 | -150 0-250 | 5610 2986 | 197 | 44 | 32414 |
| 17-J 4.000 1700 7000 2.250 0 | -150 O-250 | 6094 4301 | 489 | 73 | 32.18 |
| TUNGSTEN(K=20.,C=0.0653)-ASB | ESTOS-4130 STEEL | | | | |
| 17-A 4.000 1700 7000 2.250 0 | •150 O•250 | 6100 302 | 84 | 52 | 32.18 |
| 20-1 4.000 1700 7000 1.165 0 | 150 0.250 | <u>6102 2093</u> | 146 | 46 | 14.52 |
| TUNGSTEN(K=30.0.C=0.0653)-AS | BESTOS-4130 STEEL | | | | |
| 20-G 4.000 1700 7000 1.165 0 | 0.200 0.250 | <u>5989 2993</u> | | \$ 7 | <u> </u> |
| 21-C 4-000 1700 7000 2-250 0 | | 6103 1562 | 212 | 94 | 68.87 |
| TUNGSTEN(K=50.,C=0.0653)-ASB 17-8 4.000 1700 7000 2.250 0 | 150 0.250 | 4012 2004 | 500 | | 11 11 |
| 20-H 4-000 1700 7000 1-165 0 | 150 0-250 | 6013 2994 5 <u>542 3019</u> | | 113 33 | 32.10 |
| TUNGSTEN(K=80+0+C=0+0653)-AS | RESTOS-ALZO STEEL | 2292 3017 | 19/ | 23 | Léabé |
| 17-6 4-000 1700 7000 2-250 0 | 150 0-250 | 5603 2988 | 364 | 80 | 32.18 |
| 20-N 4-000 1700 7000 1-165 0 | | 5063 3025 | | 25 | 14.52 |
| TUNGSTEN(K=110.0.C=0.0653)-A | | L | | | |
| 17-N 4.000 1700 7000 2.250 0 | a150 0a250 | 5295 3012 | 304 | 66 | 32.18 |
| 17-N 4-000 1700 7000 2-250 0 | 150 0-250 | 6104 4861 | T 1 1 1 | 132 | 12.14 |
| 17-K 4.000 1700 7000 2.250 0 | -150 0-250 | 5296 2993 | | 36 | 32,18 |
| 17-K 4-000 1700 7000 2-250 0 | -150 0-250 | 6095 AB23 | 578 | 72 | 32.14 |
| TUNGSTEN(K=150.0.C=0.0653)-A | | | • | _ | |
| 3 17-0 4-000 1700 7000 2-250 0 | 150 0-250 | 4960 2986 | | 55 | 32.18 |
| 17-0 4-000 1700 7000 2-250 0 | •150 0•250 | 6104 5199 | | | 32.10 |
| 3-17-L 4.000 1700 7000 2.250 0 | 150 0.250 | 5962 2972 | | 34 | XIII. |
| 17-L 4.000 1700 7000 2.250 0 | 0130 00K30 | 6095 5168 | -7 | 70 | 32.18 |
| TUNGSTEN-ZRO-4130 STEEL | (MERM MOTOR DESI | GM DATAL | | | |
| 7-1A 0.700 1310 6187 1.200 0 | -450 0-250 | 5319 4600 | 424 | 105 | 6.57_ |
| 7-24 0.700 1310 6187 0.060 0 | 300 0.250 | 4862 4743 | | 4 | 0.63 |
| 7-3A 0.700 1310 6187 1.000 0 | .345 0.250 | 5274 4595 | | 74 | 4.73 |
| 7-38 0.700 1310 6187 1.000 0 | .355 0.250 | 5280 4606 | | | 4.96 |
| 7-4A 0.700 1310 6187 0.800 0 | .375 0.250 | 5219 4591 | | 49 | 3.77 |
| 7-48 0-700 1310 6187 0-800 0 | .289 0.250 | 5205 4572 | | | 3.61 |
| 7-5A 0.700 1310 6187 0.600 0 | •316 0•250 | 5162 4612 | 236 | 30 | 2.62 |
| | | | | | |

| 7-58 0-700 1310 6167 0-600 0-226 0-250 7-64 0-700 1310 6167 0-650 0-280 0-280 | 5169 4625 809 5050 4565 131 | | 47 |
|--|--------------------------------|-------|--------------------|
| 7-68 0.700 1310 6187 0.450 0.175 0.250 | 5057 4568 796 | | . 74 |
| 7-74 0-700 1310 6187 0-300 0-300 0-250 | 4983 4594 89 | 101 | |
| 7-78 0.700 1310 6167 0.300 0.131 0.250 | 4993 4610 816 | | •13 |
| 7-88 0-700 1310 6187 0-150 0-110 0-250 7-88 0-700 1310 6187 0-150 0-082 0-250 | | | - |
| 7-40 0.700 1310 5600 0.800 0.303 0.115 | 4847 4602 844 5002 4506 637 | = | 0 6 3 1 2 4 |
| 7-90 0.700 1310 3600 0.600 0.236 0.115 | 4955 4593 \$45 | | .16 |
| 7-60 0.700 1310 5600 0.450 0.183 0.115 | 4906 4587 510 | 27 7 | •47 |
| 7-70 0.700 1310 5600 0.300 0.155 0.115 | 4840 4583 311 | | .92 |
| 7-80 0-700 1310 5600 0-150 0-155 0-230 | 4795 4437 101 | | 467 |
| ATJ GRAPHITE-ZRO-4130 STEEL | | | |
| 27-A 4.000 2390 8000 0.565 0.087 0.250 | 6640 4314 249 | 8 1 | .96 |
| 21-4 4000 2370 0000 00707 0007 00270 | 00-10 4524 247 | | |
| TITANIUM CARBIDE - ASBESTOS - 4130 S | | | |
| 24-A 4.000 650 6000 1.417 0.386 0.250 | 5509 1081 102 | | 454 |
| 24-8 4.000 650 6000 0.998 0.250 0.250 | 5958 2395 347 | | • 20 |
| 8-A 4.000 1700 7000 0.140 0.040 0.250 | 5455 1934 94 | | -34 |
| TITANIUM CARBIDE-ASBESTOS(K=1.500,C').11 | - | | - 54 |
| 7-A 4.000 1700 7000 0.140 0.177 0.250 TITANIUM CARBIDE-ASBESTOS(C=0.116)-4130 | 5648 1849 114 | 31 | 56 |
| 14-A 4-000 1700 7000 0-140 0-097 0-250 | 5632 1012 132 | • • | |
| TITANIUM CARBIDE-ASBESTOS(K=1.500)-4130 | | | |
| 15-A 4.000 1700 7000 0.140 0.074 0.250 | 5664 2072 91 | 1 1 | .43 |
| 13-5 GIVE TOOL ONLY DELT | | | - |
| TITANIUM CARBIDE (K = 15.0)-ASBESTOS-4 | 130 STEEL | | |
| 14-B 4.000 1700 7000 0.465 0.100 0.250 | 5656 1968 365 | 11 2 | .45 |
| 15-B 4.000 1700 7000 0.675 0.092 0.250 | 6105 2755 175 | | 114 |
| 15-C 4.000 1700 7000 0.650 0.050 0.250 | 6093 2792 446 | 26 2 | . 77 |
| TITANIUM CARBIDE (K = 20.0)-ASBESTOS-4 | 130 STEEL | | |
| 24-C 4.000 1700 7000 0.927 0.129 0.250 | 6100 2784 196 | - | -11 |
| 24-E 4.000 1700 7000 0.900 0.075 0.250 | 6096 2832 400 | 383 | •87 |
| TITANIUM CARBIDE (K = 30.0)-ASBESTOS-4 | | 40 4 | |
| 14-C 4.000 1700 7000 1.471 0.158 0.250 | 6101 2813 258 | | • 37 |
| 14-D 4.000 1700 7000 1.450 0.120 0.250 TITANIUM CARBIDE (K = 50.0)-ASBESTOS-4 | 6106 2884 398 | 69 | j-21 |
| 24-D 4.000 1700 7000 2.727 0.213 0.250 | 6100 2898 422 | 159 1 | 2.8 |
| 24-F 4.000 1700 7000 2.700 0.200 0.250 | 6102 2922 463 | | 12.6 |
| 24-7 4000 2100 1000 28100 08200 08250 | 0102 6726 467 | | |
| TANTALUM CARBIDE-ASBESTOS-4130 STEEL | | | |
| 25-A 4.000 2390 8000 0.226 0.043 0.250 | 7052 2950 144 | 4 2 | 2067 |
| 25-8 4.000 650 6000 0.464 0.096 0.250 | 5125 3014 279 | 30 | 128 |
| 25-C 4.000 650 7000 0.236 0.056 0.250 | 5222 3064 182 | 1.25 | 1.63 |
| 25-J 4.000 650 6000 0.800 0.150 0.250 | 5402 2998 384 | 807 | 4 |
| TANTALUM CARBIDE (K = 20.0 1-ASBESTOS-4 | | | |
| 25-D 4.000 1700 7000 0.927 0.101 0.250 | 6105 2761 184 | 251 | Das |
| TANTALUM CARBIDE (K = 35.0)-ASBESTOS-4 | | | |
| 25-F 4.000 1700 7000 1.764 0.188 0.250 | 6103 2821 264 | | <u>Lear</u> |
| 25-H 4.000 1700 7000 1.650 0.100 0.250 TANTALUM CARBIDE (K = 50.0 J-ASBESTOS-4 | 6109 3004 418 | 53 1 | 17.1 |
| 25-E 4.000 1700 7000 2.730 0.168 0.250 | 6090 2832 362 | 100 | 34.9 |
| TANTALUM CARBIDE (K = 70.0)-ASBESTOS-4 | | -44 3 | , ~ • * |
| 25-6 4.000 1700 7000 4.210 0.201 0.250 | 6102 2970 600 | 195 5 | 39.8 |
| as a record and record remain record with the | | | |
| ATJ GRAPHITE-ASBESTOS-4130 STEEL | | | |
| 26-A 4.000 2390 8000 1.154 0.082 0.250 | 6712 2746 133 | 16 2 | .73 |
| | | | |

| 24 2 4 400 1700 | 7000 0 770 | | | | 100 | | |
|------------------------------------|------------|-------------|------------------------------|------|---------|-------------------------|----------------|
| 26-8 4.000 1700 26-C 4.000 650 | | | | 3064 | | 250 | 2.11 |
| 26-D 4.000 650 | 6000 Z-000 | 0.100 0.25 | 0 4533 | 3000 | | 87 | 4.39 |
| 26-E 4.000 1700 | 7000 2.000 | 0.200 0.25 | 0 5924 | 3008 | | 49 | 4060 |
| 26-F 4.000 2390 | | | | 3138 | | 11 | 2.45 |
| 26-6 4.000 2390 | 8000 ZA000 | 0.100 0.25 | 0 8892 | 1815 | 132 | 22 | 4.19 |
| TUNGSTEN - AT. | GRAPHITE | - ASBESTO | s - 4130 S | TEEL | | | |
| 18-A 4.000 1700 | 7000 0-250 | 0.500 0.10 | 0 0.250 5016 | 4013 | | | 4.18 |
| 18-A 4.000 1700 | 7000 0.250 | 0.500 0.10 | 0 0.250 6099 | 3638 | 5094 26 | 7 18 | 4.18 |
| 18-8 4.000 1700 | 7000 0.250 | 1.000 0.10 | 0 0.250 5542 | 476Z | 3032 17 | 3 20 | |
| 18-8 4.000 1700 18-C 4.000 1700 | | | | | | | |
| 18-C 4.000 1700 | 7000 0-250 | 1.500 0.10 | 0 0.250 4105 | 5617 | 3952 59 | 4 53 | |
| 16-L 4.000 1700 | 7000 0.250 | 2.000 0.05 | 0 0.250 5998 | 5447 | 3012 10 | 14 63 | 6.86 |
| 16-W 4.000 1700 | | | | | | | 4.10 |
| 16-U 4.000 1700 | | | | | | | 8.69 |
| 16-M 4.000 1700 16-V 4.000 1700 | | | | | | | 10.64 |
| 18-D 4.000 1700 | | | | | | | 13.54 |
| 18-E 4.000 1700 | | | | | | | 18,72 |
| 16-G 4.000 1700 | 7000 0.500 | 1.000 0.10 | 0 0.250 5686 | 4392 | 3100 23 | 28 | 7.76 |
| 16-H 4.000 1700 | | | | | | | 9.81 |
| 16-T 4-000 1700 | | | | | | | <u> 10a74</u> |
| 16-J 4.000 1700 16-K 4.000 1700 | | | | | | | 10.87 12.13 |
| 16-X 4.000 1700 | | | | | | | 13.63 |
| 16-9 4-000 1700 | 7000 0.750 | 1.500 0.10 | 0 0.250 5949 | 4452 | 3030 47 | 3 59 | 11.80 |
| 16-1 4.000 1700 | | | | | | | 12.92 |
| 16-2 4.000 1700 | 7000 0.750 | 2.500 0.10 | <u>0 0.250 6100</u> | 4780 | 2715 79 | 1 111 | 14015 |
| 16-Y 4.000 1700 16-0 4.000 1700 | | | | | | | 15.47 16.89 |
| 18-F 4.000 1700 | | | | | | | 13.07 |
| 18-F 4.000 1700 | | | | | | | 13.07 |
| 16-F 4.000 1700 | | | | | | | 14.05 |
| 18-7 4.000 1700 | | | | | | | |
| 18-P 4.000 1700 16-N 4.000 1700 | | | | | | | 16.12 |
| 16-E 4.000 1700 | | | | | | | 16.30 |
| 16-D 4.000 1700 | | | | | | | 16.80 |
| 16-C 4.000 1700 | 7000 1.000 | 2.350 0.10 | 0 0.250 6102 | 4435 | 2700 75 | 2 116 | 17.18 |
| 16-P 4.000 1700 | 7000 1.000 | 2.500 0.10 | 0 0.250 6103 | 4442 | 2595 74 | 122 | 17.37 |
| 16-R 4.000 1700 | | | | | | | 18.94 |
| 18-R 4.000 1700 18-G 4.000 1700 | | | | | | | |
| 18-H 4.000 1700 | | | | | | | 29.22 |
| 18-J 4.000 1700 | 7000 2.500 | 0.500 0.10 | 0 0-250 6059 | 3139 | 2999 74 | 4 98 | |
| 16-B 4.000 1700 | 7000 2.500 | 0.850 0.18 | <u>0 0.250 6108</u> | 3221 | 2959 42 | 3 120 | 39,11 |
| 18-K 4-000 1700 | | | | | | | |
| 16-L 4.000 1700 18-M 4.000 1700 | | | | | | | |
| 18-N 4-000 1700 | | | | | | | |
| 16-A 4.000 1700 | 7000 3.000 | 0.500 0.22 | 0 9.250 6109 | 2985 | | | 48.79 |
| TUNGSTEN(K=25.0) | -ATJ GRAPH | ITE-ASBESTO | 5-4130 STEEL | | | | |
| 18-5 4.000 1700 | | | | | | | |
| 18-5 4.000 1700 18-7 4.000 1700 | 7000 1-000 | 1.000 0.10 | 0 0.430 3/40 0 0.250 4042 | 3/30 | 1019 49 | 0 29 8 57 | |
| 18-U 4.000 1700 | | | | | | | |
| | | | | | | | |

| 18-H | 18-V | A-000 | 1700 | 7000 | 1.000 | 2.000 | 0-100 | 0.250 | 4000 | 4443 | 1286 | | 78 | |
|--|------------------|--------|-------|------------|---------------|---------|--------|--------|---------------|--------------|------|-----------|-----------------|-----------------|
| TUNGSTEN - BEO - ASBESTOS - A130 STEEL 19-H 4-000 1700 7000 0.790 0.790 0.790 0.100 0.290 5994 4463 2972 369 48 10.8 19-S 4-000 1700 7000 1.000 0.000 0.100 0.200 5995 6904 4463 2972 369 48 10.8 19-S 4-000 1700 7000 1.000 0.000 0.100 0.200 6030 4013 3020 502 65 14.2 19-S 4-000 1700 7000 1.000 0.000 0.000 0.200 6030 4013 3020 502 65 14.2 19-S 4-000 1700 7000 1.000 1.000 0.000 0.200 6030 4013 3020 502 65 14.2 19-S 4-000 1700 7000 1.000 1.000 0.000 0.200 6030 4013 4012 601 401 1021 | <u> 18-4</u> | A-000 | 1700 | 7000 | 1.000 | 2.500 | 0.100 | 0.250 | 4102 | 4444 | 903 | 177 | <u> </u> | _ |
| 19-H | | | | | | | | | | | | | | |
| 19-H | TUNG | LTFM . | - RFC |) - | ACRES | ros - | A130 | STEFL | | | | | | _ |
| 19-1 4-000 1700 7000 1-000 0-800 0-100 0-250 6028 4313 3020 502 65 14-2 8-K 4-000 1700 7000 1-000 0-850 0-100 0-250 6101 4441 2447 591 62 14-8 19-F 4-000 1700 7000 1-000 1-000 0-100 0-250 6101 4441 2447 591 62 14-8 19-E 4-000 1700 7000 1-000 2-000 0-100 0-250 6101 4441 2083 449 102 14-8 19-D 4-000 1700 7000 1-000 2-000 0-100 0-250 6104 4441 2083 449 102 14-8 19-B 4-000 1700 7000 3-000 0-350 0-250 6104 2442 278 342 129 48-7 19-A 4-000 1700 7000 3-000 0-350 0-250 6104 2442 278 342 129 48-7 19-A 4-000 1700 7000 3-250 0-250 0-220 0-220 6104 2744 2785 342 129 48-7 19-A 4-000 1700 7000 3-350 0-250 0-220 0-250 6104 2744 2785 342 129 48-7 19-A 4-000 1700 7000 1-000 1-000 0-300 0-250 6104 2744 2785 342 129 48-7 19-A 4-000 1700 7000 0-250 1-000 0-250 6104 2744 2785 342 129 48-7 19-A 4-000 1700 7000 0-250 1-500 0-100 0-250 5102 4476 1885 306 70 14-8 TUMGSTEN - BORON CARBIDE - ASBESTOS - 4130 STEEL 28-E 4-000 1700 7000 0-250 1-500 0-100 0-250 5229 4401 726 87 24 6.73 28-D 4-000 1700 7000 0-250 1-500 0-100 0-250 5522 3451 145 85 26 7-82 28-B 4-000 1700 7000 0-750 2-000 0-100 0-250 5542 3357 2979 2626 88 14-0 28-C 4-000 1700 7000 0-750 3-000 0-100 0-250 5542 3357 2979 2626 88 14-0 28-K 4-000 1700 7000 0-750 3-000 0-100 0-250 6102 4765 1824 601 190 170 780 28-K 4-000 1700 7000 1-000 1-000 0-100 0-250 600 4383 2226 767 150 28-K 4-000 1700 7000 1-000 1-000 0-100 0-250 600 4383 2226 767 150 28-A 4-000 1700 7000 1-000 1-000 0-100 0-250 600 4383 2226 767 150 28-A 4-000 1700 7000 1-000 2-000 0-100 0-250 600 4383 2226 767 150 28-A 4-000 1700 7000 1-000 2-000 0-100 0-250 600 4383 2226 767 150 28-A 4-000 1700 7000 1-000 2-000 0-100 0-250 600 4383 2226 767 150 28-A 4-000 1700 7000 1-000 2-000 0-100 0-250 600 4383 2226 767 150 28-A 4-000 1700 7000 1-000 2-000 0-200 0-200 600 4383 2226 767 150 28-A 4-000 1700 7000 1-000 2-000 0-200 0-250 600 4383 2226 767 150 28-A 4-000 1700 7000 1-000 2-000 0-200 0-250 600 4383 2226 767 150 28-A 4-000 1700 7000 1-000 2-000 0-200 0-250 600 4383 2226 767 150 15-28-48 4-000 1700 7000 1-000 0-200 0-200 0-2 | 19-H | 4.000 | 1700 | 7000 | 0.750 | 0.750 | 0.100 | 0.250 | 5944 | 4463 | 2972 | 369 | 48 | 10.84 |
| 18=E 4.000 1700 7000 1.000 0.100 0.250 6101 4481 2447 523 49 182 18-F 4.000 1700 7000 1.000 1.000 0.100 0.250 6101 4481 2447 91 82 14.8 19-E 4.000 1700 7000 1.000 1.000 0.100 0.250 6101 4481 2447 91 82 14.8 19-D 4.000 1700 7000 1.000 2.000 0.100 0.250 6101 4481 2487 91 122 14.8 19-D 4.000 1700 7000 1.000 2.000 0.100 0.250 6101 4482 911 228 114 18.1 19-E 4.000 1700 7000 3.000 0.350 0.200 0.250 6104 2944 2784 342 129 48.7 19-B 4.000 1700 7000 3.000 0.350 0.200 0.250 6104 2944 2784 342 129 48.7 19-B 4.000 1700 7000 3.000 0.350 0.200 0.250 6104 2944 2784 342 129 48.7 19-B 4.000 1700 7000 1.000 0.200 0.220 0.2250 6102 2746 2681 316 136 36.3 19-A 4.000 1700 7000 1.000 0.000 0.220 0.250 6102 2476 1885 306 70 14.8 19-L 4.000 1700 7000 0.250 1.500 0.100 0.250 6102 4476 1885 306 70 14.8 19-L 4.000 1700 7000 0.250 1.500 0.100 0.250 5229 3401 726 87 24 6.73 28-D 4.000 1700 7000 0.250 1.500 0.100 0.250 5325 334 3454 145 85 26 9.63 28-E 4.000 1700 7000 0.250 2.500 0.100 0.250 5542 3357 2997 2266 88 14.0 28-E 4.000 1700 7000 0.750 2.000 0.100 0.250 5542 3357 2997 2266 88 14.0 28-E 4.000 1700 7000 0.750 3.000 0.100 0.250 5102 3455 1024 401 190 17.7 28-K 4.000 1700 7000 0.750 3.000 0.100 0.250 5102 3455 1024 60 190 17.7 28-K 4.000 1700 7000 0.750 3.000 0.100 0.250 50102 3455 1024 60 77 14 52-K 4.000 1700 7000 1.000 1.000 1.000 0.1000 0.250 6084 343 2326 767 150 28-H 4.000 1700 7000 1.000 1.000 0.1000 0.250 6084 3403 3021 57 101 15.3 28-H 4.000 1700 7000 1.000 1.000 0.1000 0.250 6080 4363 2326 767 150 28-H 4.000 1700 7000 1.000 0.2000 0.100 0.250 6080 4363 2326 767 150 28-H 4.000 1700 7000 1.000 2.000 0.100 0.250 6080 4363 2326 767 150 28-H 4.000 1700 7000 1.000 2.000 0.100 0.250 6080 4363 2326 767 150 28-H 4.000 1700 7000 1.000 2.000 0.100 0.250 6080 4363 2326 767 150 28-H 4.000 1700 7000 0.000 0.000 0.000 0.250 6090 4080 4363 2326 767 150 28-H 4.000 1700 7000 0.000 0.000 0.000 0.250 6090 4080 4363 2326 60 77 14 28-H 4.000 1700 7000 0.000 0.000 0.000 0.250 6090 4080 4363 2326 60 77 14 28-H 4.000 1700 7000 0.000 0.000 0.000 0.25 | 19-G | 4.000 | 1700 | 7000 | 1.000 | 0.750 | 0.100 | 0.250 | 6000 | 4238 | 3009 | 442 | 60 | _عدمقت |
| 19-F 4-000 1700 7000 1-000 1-000 0-100 0-250 6101 4481 2447 991 82 14-8 19-E 4-000 1700 7000 1-000 1-000 0-100 0-250 6105 4491 1028 449 102 18-E 4-000 1700 7000 1-000 2-000 0-100 0-250 6105 4495 1328 323 114 18-1 19-C 4-000 1700 7000 1-000 0-350 0-200 0-250 6105 4495 1328 323 114 18-1 19-C 4-000 1700 7000 3-000 0-350 0-200 0-250 6101 4200 911 228 116 17-8 19-B 4-000 1700 7000 3-350 0-200 0-250 6101 4200 911 228 116 17-8 19-B 4-000 1700 7000 3-350 0-250 0-220 0-250 6101 2748 2681 316 136 56-3 19-C 4-000 1700 7000 1-3550 0-250 0-220 0-250 6101 2748 2681 316 136 56-3 19-C 4-000 1700 7000 1-000 0-1000 0-100 0-250 5102 4476 1885 306 70 14-8 TUMGSTEN - BORN CARBIDE - ASBESTOS - 4130 STEEL 28-C 4-000 1700 7000 0-250 1-500 0-100 0-250 5252 9401 726 87 24 6-73 28-D 4-000 1700 7000 0-250 2-500 0-100 0-250 5363 4494 3695 85 26 9-63 28-B 4-000 1700 7000 0-750 2-500 0-100 0-250 5363 4494 3087 949 114 15-8 28-A 4-000 1700 7000 0-750 3-000 0-100 0-250 5570 3424 3087 949 114 15-8 28-A 4-000 1700 7000 0-750 3-000 0-100 0-250 570 3424 3087 949 114 15-8 28-A 4-000 1700 7000 1-000 1-000 0-100 0-250 5970 4115 3021 60 77 14 6 28-M 4-000 1700 7000 1-000 1-000 0-100 0-250 5970 4115 3021 60 77 14 6 28-M 4-000 1700 7000 1-000 1-000 0-100 0-250 6102 4765 1624 601 190 170- 28-K 4-000 1700 7000 1-000 1-000 0-100 0-250 6101 4403 1257 77 180 12-8 28-A 4-000 1700 7000 1-000 1-000 0-100 0-250 6101 4403 1257 77 180 12-8 28-A 4-000 1700 7000 1-000 1-000 0-100 0-250 6101 4403 1257 77 180 12-8 28-A 4-000 1700 7000 1-000 1-000 0-100 0-250 6101 4403 1257 77 180 12-8 28-A 4-000 1700 7000 1-000 1-000 0-250 6101 4403 1257 77 180 12-8 28-A 4-000 1700 7000 1-000 1-000 0-250 6101 4403 1257 77 180 12-8 28-A 4-000 1700 7000 1-000 0-250 0-100 0-250 6101 4403 1257 77 180 12-8 28-A 4-000 1700 7000 1-000 0-250 0-100 0-250 6101 4403 1257 77 180 12-8 28-A 4-000 1700 7000 0-000 0-000 0-250 6101 4403 1257 77 180 12-8 28-A 4-000 1700 7000 0-000 0-000 0-250 6101 4403 1257 77 180 12-8 28-A 4-000 1700 7000 0-000 0-000 0-250 6101 4403 1257 77 180 12-8 28-A 4-000 1700 7 | | | | | | | | | | | | | | 14.28 |
| 19-E 4-000 1700 7000 1-000 2-000 0-100 0-250 6105 4491 2083 449 102 16-0 4-000 1700 7000 1-000 2-000 0-100 0-250 6105 4495 1328 329 114 18-1 19-E 4-000 1700 7000 1-000 2-350 0-100 0-250 6101 4420 911 228 114 19-E 19-E 4-000 1700 7000 3-000 0-350 0-100 0-250 6101 4420 911 228 114 19-E 19-E 4-000 1700 7000 3-000 0-350 0-250 0-250 6104 2944 2786 342 129 48-7 19-E 4-000 1700 7000 3-000 0-350 0-250 0-250 6104 2944 2786 342 129 48-7 19-E 4-000 1700 7000 3-000 0-350 0-250 0-250 6102 4476 1889 306 70 14-E 19-E 4-000 1700 7000 1-000 0-1000 0-100 0-250 6102 4476 1889 306 70 14-E 19-E 4-000 1700 7000 1-000 1-000 0-100 0-250 5129 4401 726 87 24 6-73 28-D 4-000 1700 7000 0-250 1-500 0-100 0-250 5129 4401 726 87 24 6-73 28-D 4-000 1700 7000 0-250 2-300 0-100 0-250 5129 4401 726 87 24 6-73 28-D 4-000 1700 7000 0-250 2-300 0-100 0-250 5542 3957 2997 2626 88 14-0 28-E 4-000 1700 7000 0-750 2-000 0-100 0-250 5542 3957 2997 2626 88 14-0 28-E 4-000 1700 7000 0-750 2-000 0-100 0-250 5542 3957 2997 2626 88 14-0 28-E 4-000 1700 7000 0-750 3-000 0-100 0-250 5040 3957 2997 1626 88 14-0 28-E 4-000 1700 7000 0-750 3-000 0-100 0-250 6102 4475 1624 601 190 17-7 28-E 4-000 1700 7000 0-750 3-000 0-100 0-250 6102 4475 1624 601 190 17-7 28-E 4-000 1700 7000 1-000 1-000 0-100 0-250 6102 4475 1624 601 190 17-7 28-E 4-000 1700 7000 1-000 1-000 0-1000 0-250 6102 4455 1624 601 190 17-7 28-E 4-000 1700 7000 1-000 1-000 0-1000 0-250 6000 4363 2326 767 150 28-H 4-000 1700 7000 1-000 2-0000 0-100 0-250 6000 4363 2326 767 150 28-H 4-000 1700 7000 1-000 2-0000 0-100 0-250 6000 4363 2326 767 150 28-H 4-000 1700 7000 1-000 3-000 0-100 0-250 6000 4363 2326 767 150 28-H 4-000 1700 7000 1-000 3-000 0-100 0-250 6101 4403 1537 507 2000 21.50 2-000 0-100 0-250 6101 4403 1537 507 2000 21.50 2-000 0-100 0-250 6101 4403 1537 507 2000 21.50 2-000 0-100 0-250 6000 4363 2326 767 150 28-H 4-000 1700 7000 1-000 2-000 0-100 0-250 6000 4363 2326 767 150 2000 0-100 0-250 6000 4363 2326 767 150 2000 0-100 0-250 6000 4400 1507 500 2000 0-100 0-250 6000 4400 1507 500 2000 0-1 | | | | | | | | | | | | | | <u> 18482</u> . |
| 19-0 4-000 1700 7000 1-000 2-000 0-100 0-250 6105 4495 1328 323 14 14 18-19-C 4-000 1700 7000 1-000 2-350 0-100 0-250 6104 2944 2786 362 129 48-7 19-A 4-000 1700 7000 3-300 0-250 0-200 0-250 6104 2944 2786 362 129 48-7 19-A 4-000 1700 7000 3-350 0-250 0-220 0-250 6101 2748 2681 316 136 58-3 19-A 4-000 1700 7000 1-300 1-000 0-1000 0-250 6101 2748 2681 316 136 58-3 19-A 4-000 1700 7000 1-000 1-000 0-1000 0-250 6102 4476 1885 304 70 14-8 19-A 4-000 1700 7000 0-250 1-500 0-100 0-250 6102 4476 1885 304 70 14-8 19-A 4-000 1700 7000 0-250 1-500 0-100 0-250 5129 4401 726 87 24 6-73 28-0 4-000 1700 7000 0-250 1-500 0-100 0-250 5129 4401 726 87 24 6-73 28-0 4-000 1700 7000 0-250 2-500 0-100 0-250 5229 4401 726 87 24 6-73 28-0 4-000 1700 7000 0-250 2-500 0-100 0-250 5229 4401 726 87 24 6-73 28-0 4-000 1700 7000 0-250 2-500 0-100 0-250 5363 4454 145 85 26 9-85 28-0 4-000 1700 7000 0-750 2-5000 0-100 0-250 5363 4454 145 85 26 9-85 28-0 4-000 1700 7000 0-750 2-5000 0-100 0-250 5502 3957 2997 2626 88 14-0 28-0 4-000 1700 7000 0-750 3-5000 0-100 0-250 5102 4765 1624 401 190 17-7 28-K 4-000 1700 7000 0-750 3-5000 0-100 0-250 6102 4765 1624 401 190 17-7 28-K 4-000 1700 7000 0-750 3-5000 0-100 0-250 6102 4765 1624 401 190 17-7 28-K 4-000 1700 7000 1-000 1-000 0-100 0-250 6102 4765 1624 401 190 17-7 28-K 4-000 1700 7000 1-000 1-000 0-100 0-250 6102 4765 1624 401 190 17-7 28-A 4-000 1700 7000 1-000 1-000 0-1000 0-250 6101 4403 1537 507 110 12-3 28-A 4-000 1700 7000 1-000 1-000 1-000 0-100 0-250 6101 4403 1537 507 150 12-4 28-A 4-000 1700 7000 1-000 1-000 1-000 0-100 0-250 6101 4403 1537 507 150 12-4 28-A 4-000 1700 7000 1-000 1-000 0-1000 0-250 6101 4403 1537 507 150 12-4 28-A 4-000 1700 7000 1-000 0-1000 0-1000 0-250 6101 4403 1537 507 150 15-4 28-A 4-000 1700 7000 1-000 0-1000 0-1000 0-250 6101 4403 1537 507 150 15-4 28-A 4-000 1700 7000 1-000 0-1000 0-200 0-250 6103 4416 1367 727 182 19-4 28-A 4-000 1700 7000 0-1000 0-1000 0-200 0-250 6103 4416 1367 727 182 19-4 18 18 18 18 18 18 18 18 18 18 18 18 18 | 19-F | A-000 | 1700 | 7000 | 1.000 | 1.500 | 0-100 | 0-250 | 4101 | 4441 | 2088 | 771 | | T . T . I |
| 19-6 4-000 1700 7000 3.000 0.350 0.200 0.250 6104 2944 2786 362 129 48.7 19-8 4.000 1700 7000 3.000 0.350 0.200 0.250 6104 2944 2786 362 129 48.7 19-8 4.000 1700 7000 3.350 0.250 0.220 0.250 6104 2944 2786 362 129 48.7 19-8 4.000 1700 7000 3.350 0.250 0.250 6104 2944 2786 362 129 48.7 19-8 4.000 1700 7000 1.0000 1.000 0.100 0.250 6102 4476 1885 306 70 14.8 19-8 19-8 19-8 19-8 19-8 19-8 19-8 19- | 19-D | 4.000 | 1700 | 7000 | 1.000 | 2.000 | 0.100 | 0.250 | 6105 | 4435 | 1328 | 323 | _ | 18.16 |
| 19-A 4.000 1700 7000 3.350 0.250 0.220 0.250 0.101 2748 2681 316 136 56.3 19-K 4.000 1700 7000 1.000 1.000 0.250 0.102 4476 1885 306 70 14.8 19-K 4.000 1700 7000 0.250 1.000 0.250 0.102 0.250 0.102 4476 1885 306 70 14.8 19-K 4.000 1700 7000 0.250 1.500 0.100 0.250 529 4401 726 87 24 6.73 28-E 4.000 1700 7000 0.250 2.500 0.100 0.250 5363 4454 145 85 26 9.63 28-B 4.000 1700 7000 0.250 2.500 0.100 0.250 5363 4454 145 85 26 9.63 28-B 4.000 1700 7000 0.250 2.500 0.100 0.250 5363 4454 145 85 26 9.63 28-E 4.000 1700 7000 0.750 2.500 0.100 0.250 5570 3426 3007 949 114 15.3 28-B 4.000 1700 7000 0.750 3.000 0.100 0.250 6577 3426 3007 949 114 15.3 28-B 4.000 1700 7000 1.500 1.000 0.100 0.250 6097 4755 1211 440 200 17.0 28-K 4.000 1700 7000 1.000 1.250 0.100 0.250 6097 4755 1211 440 200 19.6 28-H 4.000 1700 7000 1.000 1.250 0.100 0.250 6080 4363 3001 757 101 12.3 28-A 4.000 1700 7000 1.000 1.250 0.100 0.250 6080 4363 3001 757 101 12.3 28-A 4.000 1700 7000 1.000 3.500 0.100 0.250 6080 4363 3001 757 101 12.3 28-A 4.000 1700 7000 1.000 3.500 0.100 0.250 6080 4363 3001 757 101 12.3 28-B 4.000 1700 7000 1.000 3.500 0.100 0.250 6080 4363 3001 757 727 122 12.4 28-B 4.000 1700 7000 1.000 3.500 0.100 0.250 6101 4403 1537 587 200 21.5 28-B 4.000 1700 7000 1.000 2.000 0.200 0.250 6092 6101 6403 1537 587 200 21.5 28-B 4.000 1700 7000 1.000 2.000 0.250 6092 6101 6403 1537 587 200 21.5 | 19-C | 4.000 | 1700 | 7000 | 1.000 | 2.350 | 0.100 | 0.250 | 6101 | 4420 | 911 | 221 | | 19.44 |
| TUMGSTEN-BEGO(K=15.)—ASBESTOS—4130 STEEL 19-L 4-000 1700 7000 1-000 1-000 0-100 0-250 6102 4476 1885 306 70 10-SET — BORON CARBIDE — ASBESTOS — 4130 STEEL 28-E 4-000 1700 7000 0-250 1-500 0-100 0-250 5229 4401 726 87 24 6-73 28-D 4-000 1700 7000 0-250 2-500 0-100 0-250 5263 4454 145 85 26 9-62 28-B 4-000 1700 7000 0-750 2-500 0-100 0-250 5263 4454 145 85 26 9-62 28-C 4-000 1700 7000 0-750 2-500 0-100 0-250 5263 4354 145 85 26 9-62 28-C 4-000 1700 7000 0-750 3-500 0-100 0-250 5263 4354 145 85 26 9-62 28-C 4-000 1700 7000 0-750 3-500 0-100 0-250 5402 3357 2997 2626 86 14-0 28-N 4-000 1700 7000 1-000 1-000 0-100 0-250 6102 4765 1624 601 190 17-7 28-N 4-000 1700 7000 1-000 1-000 0-100 0-250 5970 4115 3021 60 77 14 62 28-N 4-000 1700 7000 1-000 1-000 0-100 0-250 5970 4115 3021 60 77 14 62 28-N 4-000 1700 7000 1-000 1-000 0-100 0-250 5970 415 3021 60 77 14 62 28-N 4-000 1700 7000 1-000 2-000 0-100 0-250 5970 415 3021 60 77 14 15-30 28-A 4-000 1700 7000 1-000 2-000 0-100 0-250 6004 4302 3001 737 101 15-3 28-A 4-000 1700 7000 1-000 2-000 0-100 0-250 6004 4302 3001 737 101 15-3 28-A 4-000 1700 7000 1-000 2-000 0-100 0-250 6103 4416 1967 727 182 19-4 28-L 4-000 1700 7000 1-000 3-500 0-100 0-250 6101 4403 1537 587 200 21-3 28-M 4-000 1700 7000 1-000 3-500 0-100 0-250 6101 4403 1537 587 200 21-3 28-M 4-000 1700 7000 1-000 3-500 0-100 0-250 5772 3510 2996 170 108 15-4 30-A 4-000 1700 7000 1-000 0-200 0-200 0-250 5772 3510 2996 170 108 15-4 30-A 4-000 1700 7000 1-000 0-200 0-200 0-250 599 4044 118 510 200 11-4 30-B 4-000 1700 7000 1-000 1-000 0-200 0-250 599 4048 118 510 200 11-4 30-B 4-000 1700 7000 0-750 2-000 0-200 0-250 6009 4028 4118 510 200 11-4 30-B 4-000 1700 7000 0-750 2-000 0-200 0-250 6009 4028 4118 510 200 11-4 30-B 4-000 1700 7000 0-750 2-000 0-200 0-250 6009 4028 4118 510 200 11-4 30-B 4-000 1700 7000 0-750 2-000 0-200 0-250 6009 4028 4118 510 200 11-4 30-B 4-000 1700 7000 0-750 2-000 0-250 6009 5007 5317 115 50 5-51 PYRO GRAPHITE — PYRO GRAPHITE — 4130 STEEL 31-A 4-000 1700 7000 2- | 19-B | 4.000 | 1700 | 7000 | 3.000 | 0.350 | 0.200 | 0.250 | 6104 | 2944 | 2786 | 362 | | 48.76 |
| TUMGSTEN - BORON CARBIDE - ASBESTOS - 4130 STEEL 28-E 4-000 1700 7000 0-250 1-500 0-100 0-250 5263 4454 145 85 26 9-62 28-D 4-000 1700 7000 0-250 2-500 0-100 0-250 5263 4454 145 85 26 9-62 28-B 4-000 1700 7000 0-750 2-000 0-100 0-250 5363 4454 145 85 26 9-62 28-B 4-000 1700 7000 0-750 2-000 0-100 0-250 5363 4454 145 85 26 9-62 28-C 4-000 1700 7000 0-750 2-000 0-100 0-250 5363 4454 145 85 26 9-62 28-C 4-000 1700 7000 0-750 2-000 0-100 0-250 5363 4454 145 85 26 9-62 28-C 4-000 1700 7000 0-750 3-000 0-100 0-250 5570 3426 3007 949 114 15-42 28-K 4-000 1700 7000 0-750 3-000 0-100 0-250 6102 4765 1624 601 190 17-7 28-K 4-000 1700 7000 1-070 3-000 0-100 0-250 6102 4765 1624 601 190 17-7 28-H 4-000 1700 7000 1-000 1-000 0-100 0-250 6102 4765 1624 601 190 17-7 28-A 4-000 1700 7000 1-000 1-000 0-100 0-250 6000 4363 2326 767 150 28-B 4-000 1700 7000 1-000 2-000 0-100 0-250 6000 4363 2326 767 150 28-B 4-000 1700 7000 1-000 3-000 0-100 0-250 6000 4363 2326 767 150 28-B 4-000 1700 7000 1-000 3-000 0-100 0-250 6000 4363 2326 767 150 28-B 4-000 1700 7000 1-000 3-000 0-100 0-250 6101 4403 1375 567 200 21-3 28-B 4-000 1700 7000 1-000 3-000 0-100 0-250 6101 4403 1375 767 200 23-3 TUMGSTEN - PYRO GRAPHITE - PYRO GRAPHITE - 4130 STEEL 30-A 4-000 1700 7000 1-000 3-000 0-200 0-250 6099 4504 4318 177 87 14-4 30-B 4-000 1700 7000 1-000 2-000 0-200 0-250 6099 4504 4318 177 87 14-4 30-B 4-000 1700 7000 0-850 2-000 0-200 0-250 6099 4504 4318 177 87 14-4 30-B 4-000 1700 7000 0-850 2-000 0-200 0-250 6099 4504 4318 177 87 14-4 30-B 4-000 1700 7000 0-850 2-000 0-200 0-250 6099 4504 4318 177 87 14-4 30-B 4-000 1700 7000 0-850 2-000 0-200 0-250 6099 4504 4318 177 87 14-4 30-B 4-000 1700 7000 0-850 2-000 0-200 0-250 6099 4504 4318 177 87 14-4 30-B 4-000 1700 7000 0-850 0-100 0-200 0-250 6099 4504 4318 177 87 14-4 30-B 4-000 1700 7000 0-850 0-100 0-200 0-250 6099 4504 4318 171 15 50 5-54 30-B 4-000 1700 7000 0-850 0-100 0-200 0-250 6099 4504 4318 171 15 50 5-54 30-B 4-000 1700 7000 0-850 0-100 0-250 6099 4504 4318 171 | | | | | | | | | 6101 | 2768 | 2681 | _316_ | 136 | <u> -56.37</u> |
| TUNGSTEN - BORON CARBIDE - ASBESTOS - 4130 STEEL 28-E 4.000 1700 7000 0.250 1.500 0.100 0.250 5:29 4401 726 87 24 6.73 28-0 4.000 1700 7000 0.250 2.500 0.100 0.250 5363 4454 145 87 26 9.63 28-B 4.000 1700 7000 0.750 2.000 0.010 0.250 5363 4454 145 87 26 9.63 28-C 4.000 1700 7000 0.750 2.000 0.010 0.250 5570 3426 3007 949 114 15.63 28-J 4.000 1700 7000 0.750 3.000 0.100 0.250 5570 3426 3007 949 114 15.63 28-J 4.000 1700 7000 0.750 3.000 0.100 0.250 6102 4765 1624 601 190 17.0 28-K 4.000 1700 7000 1.000 1.000 0.100 0.250 6007 4750 1211 450 200 19.0 28-N 4.000 1700 7000 1.000 1.000 0.100 0.250 6007 4750 1211 450 200 19.0 28-N 4.000 1700 7000 1.000 1.000 0.100 0.250 6008 4308 3001 757 101 15.3 28-A 4.000 1700 7000 1.000 2.000 0.100 0.250 6000 4363 3226 767 150 28-A 4.000 1700 7000 1.000 2.000 0.100 0.250 6000 4363 3226 767 150 28-A 4.000 1700 7000 1.000 2.500 0.100 0.250 6000 4363 3226 767 150 28-A 4.000 1700 7000 1.000 3.000 0.100 0.250 6103 4416 1967 727 182 19.4 28-L 4.000 1700 7000 1.000 3.000 0.100 0.250 6101 4403 1537 507 200 21.3 28-B 4.000 1700 7000 1.000 3.000 0.100 0.250 6101 4403 1537 507 200 21.3 28-B 4.000 1700 7000 1.000 3.000 0.200 0.250 6101 4403 1537 507 200 21.3 30-A 4.000 1700 7000 1.000 3.000 0.200 0.250 6101 4403 1537 507 200 21.3 30-A 4.000 1700 7000 1.000 0.200 0.200 0.250 6101 4403 1537 507 200 21.3 30-A 4.000 1700 7000 1.000 0.000 0.200 0.250 6101 4003 1537 507 200 21.3 30-B 4.000 1700 7000 0.000 0.000 0.200 0.250 6009 4504 4318 177 77 14.4 30-B 4.000 1700 7000 0.750 2.000 0.200 0.250 6009 4504 4318 177 77 14.4 30-B 4.000 1700 7000 0.750 2.000 0.200 0.250 6009 4504 4318 177 87 14.4 30-B 4.000 1700 7000 0.750 2.000 0.200 0.250 6009 4504 4318 177 87 14.4 30-B 4.000 1700 7000 0.750 2.000 0.200 0.250 6009 4504 4318 177 87 14.4 30-B 4.000 1700 7000 0.750 0.000 0.200 0.250 6009 4504 4318 177 87 14.4 30-B 4.000 1700 7000 0.750 0.000 0.200 0.250 6009 4504 4318 177 87 14.4 30-B 4.000 1700 7000 0.750 0.000 0.200 0.250 6009 4504 4318 177 87 14.4 30-B 4.000 1700 7000 0.750 0 | | | | | | | | | 4100 | 4474 | 1005 | 904 | 70 | 14 84 |
| 28-E 4.000 1700 7000 0.250 1.500 0.100 0.250 5229 4401 726 87 24 6.72 28-D 4.000 1700 7000 0.250 2.500 0.100 0.250 5543 4554 145 85 26 9.65 28-C 4.000 1700 7000 0.750 2.000 0.010 0.250 5542 3357 2997 2626 88 14.0 28-C 4.000 1700 7000 0.750 2.000 0.100 0.250 5570 3426 3007 947 114 15.4 28-J 4.000 1700 7000 0.750 3.000 0.100 0.250 6102 4765 1624 601 190 170. 28-K 4.000 1700 7000 0.750 3.500 0.100 0.250 6102 4765 1624 601 190 170. 28-K 4.000 1700 7000 1.000 1.000 0.100 0.250 6007 4790 1211 450 200 170. 28-H 4.000 1700 7000 1.000 1.000 0.100 0.250 6007 4790 1211 450 200 170. 28-H 4.000 1700 7000 1.000 1.250 0.100 0.250 6004 3430 3001 757 101 15.3 28-A 4.000 1700 7000 1.000 2.500 0.100 0.250 6004 3430 3001 757 101 15.3 28-A 4.000 1700 7000 1.000 2.500 0.100 0.250 6004 3430 3226 767 150 28-G 4.000 1700 7000 1.000 2.500 0.100 0.250 6004 3430 3226 767 150 28-H 4.000 1700 7000 1.000 2.500 0.100 0.250 6103 4416 1967 727 182 19.4 28-L 4.000 1700 7000 1.000 3.5000 0.100 0.250 6103 4416 1967 727 182 19.4 28-L 4.000 1700 7000 1.000 3.5000 0.100 0.250 6101 4403 1537 587 200 21.3 28-H 4.000 1700 7000 1.000 3.5000 0.100 0.250 6101 4403 1537 587 200 21.3 28-H 4.000 1700 7000 1.000 3.5000 0.100 0.250 6101 4403 1537 587 200 21.3 28-H 4.000 1700 7000 1.000 3.5000 0.200 0.250 5772 3510 2996 170 108 15.4 30-A 4.000 1700 7000 1.000 2.000 0.200 0.250 5772 3510 2996 170 108 15.4 30-A 4.000 1700 7000 1.000 2.000 0.200 0.250 6099 4504 4318 517 87 14.3 30-B 4.000 1700 7000 0.850 2.000 0.200 0.250 6099 4504 4318 517 87 14.3 30-B 4.000 1700 7000 0.850 2.000 0.200 0.250 6099 4504 4318 517 87 14.3 30-B 4.000 1700 7000 0.750 2.000 0.200 0.250 6099 4504 4318 517 87 14.3 30-B 4.000 1700 7000 0.750 2.000 0.200 0.250 6099 4504 4318 517 87 14.3 30-B 4.000 1700 7000 0.750 2.000 0.200 0.250 6099 4504 4318 510 320 14.3 30-B 4.000 1700 7000 0.750 0.000 0.200 0.250 6099 4504 4318 5078 313 134 10.3 30-B 4.000 1700 7000 0.250 0.000 0.250 6099 4504 4318 5078 313 135 10.3 30-B 4.000 1700 7000 0.250 0.000 0.250 6099 4504 4318 5078 313 135 10.3 31-B 4.000 1700 | 17=1 | 7.000 | 1700 | 7000 | 1.000 | 1.000 | 0.100 | UAZZU | DIUZ | 77/0 | 1002 | 300 | 70 | _14486_ |
| 28-E 4.000 1700 7000 0.250 1.500 0.100 0.250 5229 4401 726 87 24 6.72 28-D 4.000 1700 7000 0.250 2.500 0.100 0.250 5363 4454 145 85 26 9.65 28-E 4.000 1700 7000 0.750 2.000 0.010 0.250 5542 3357 2997 2626 88 14.0 28-C 4.000 1700 7000 0.750 2.000 0.100 0.250 5542 3357 2997 2626 88 14.0 28-C 4.000 1700 7000 0.750 2.500 0.100 0.250 6504 3367 2997 114 15.4 28-Y 4.000 1700 7000 0.750 3.000 0.100 0.250 6102 4765 1624 601 190 170. 28-K 4.000 1700 7000 1.000 1.000 0.250 6102 4765 1624 601 190 170. 28-K 4.000 1700 7000 1.000 1.000 0.250 6009 4763 1624 601 190 170. 28-H 4.000 1700 7000 1.000 1.000 0.250 6009 4363 3001 757 101 15.3 28-A 4.000 1700 7000 1.000 2.000 0.100 0.250 6008 4362 3001 757 101 15.3 28-A 4.000 1700 7000 1.000 2.000 0.100 0.250 6008 4362 3001 757 101 15.3 28-A 4.000 1700 7000 1.000 2.000 0.100 0.250 6008 4362 3226 767 150 28-A 4.000 1700 7000 1.000 2.5000 0.100 0.250 6008 4362 3226 767 150 28-A 4.000 1700 7000 1.000 2.5000 0.100 0.250 6101 4403 1537 587 200 21.3 28-M 4.000 1700 7000 1.000 3.5000 0.100 0.250 6101 4403 1537 587 200 21.3 28-M 4.000 1700 7000 1.000 3.5000 0.100 0.250 6101 4403 1537 587 200 21.3 28-M 4.000 1700 7000 1.000 3.5000 0.200 0.250 5772 3510 2996 170 108 15.4 30-A 4.000 1700 7000 1.000 2.000 0.200 0.250 5772 3510 2996 170 108 15.4 30-A 4.000 1700 7000 1.000 2.000 0.200 0.250 6099 4504 4318 517 87 14.1 30-A 4.000 1700 7000 1.000 2.000 0.200 0.250 6099 4504 4318 517 87 14.1 30-B 4.000 1700 7000 0.750 2.000 0.200 0.250 6099 4504 4318 510 200 17.4 30-B 4.000 1700 7000 0.750 2.000 0.200 0.250 6099 4504 4318 510 200 17.4 30-B 4.000 1700 7000 0.750 2.000 0.200 0.250 6099 4504 4318 510 200 17.4 30-B 4.000 1700 7000 0.750 2.000 0.200 0.250 6099 4504 4318 510 19.4 30-B 4.000 1700 7000 0.750 2.000 0.200 0.250 6099 4504 4318 510 19.4 30-B 4.000 1700 7000 0.750 2.000 0.250 6099 4504 4318 510 13.8 30-B 4.000 1700 7000 0.750 2.000 0.250 6099 4504 4308 303 138 134 10.3 30-B 4.000 1700 7000 0.250 0.000 0.250 6099 4504 4308 5078 311 115 50 5.55 | TUNG | STEN . | - BOI | RON C | ARBIDE | - AS | BESTO | s - 4 | 130 | STEE | L | | | |
| 28-B 4.000 1700 7000 0.250 2.500 0.100 0.250 5363 4454 145 85 26 9.65 28-B 4.000 1700 7000 0.750 2.000 0.010 0.250 5542 3357 2997 2626 88 14.0 28-C 4.000 1700 7000 0.750 3.000 0.100 0.250 5570 3424 3007 949 114 15.3 28-J 4.000 1700 7000 0.750 3.500 0.100 0.250 6102 4765 1624 601 190 17.7 28-K 4.000 1700 7000 1.000 1.000 0.100 0.250 6097 4750 1211 450 200 192.8 28-N 4.000 1700 7000 1.000 1.000 0.100 0.250 6097 4750 1211 450 200 192.8 28-N 4.000 1700 7000 1.000 1.000 0.100 0.250 6097 4750 1211 450 200 192.8 28-N 4.000 1700 7000 1.000 2.000 0.100 0.250 6084 4308 3001 757 101 15.3 28-A 4.000 1700 7000 1.000 2.000 0.100 0.250 6084 4308 3001 757 101 15.3 28-A 4.000 1700 7000 1.000 2.000 0.100 0.250 6080 4363 2326 767 150 28-4 4.000 1700 7000 1.000 2.500 0.100 0.250 6103 4416 1967 727 182 19.4 28-L 4.000 1700 7000 1.000 3.000 0.100 0.250 6103 4416 1967 727 182 19.4 28-L 4.000 1700 7000 1.000 3.000 0.100 0.250 6101 4403 1537 587 200 21.3 28-M 4.000 1700 7000 1.000 3.500 0.100 0.250 6101 4403 1537 587 200 21.3 28-M 4.000 1700 7000 1.000 2.000 0.200 0.250 6101 4403 1537 587 200 21.3 28-M 4.000 1700 7000 1.000 2.000 0.200 0.250 5772 3510 2996 170 108 15.6 30-A 4.000 1700 7000 1.000 2.000 0.200 0.250 5772 3510 2996 170 108 15.6 30-A 4.000 1700 7000 1.000 2.000 0.200 0.250 6025 4227 3810 322 150 15.4 30-B 4.000 1700 7000 0.850 2.500 0.200 0.250 6095 4024 4318 510 206 17.6 30-B 4.000 1700 7000 0.850 2.500 0.200 0.250 6095 4042 4318 510 206 17.6 30-B 4.000 1700 7000 0.750 2.000 0.200 0.250 6095 4042 4318 510 206 17.6 30-B 4.000 1700 7000 0.750 2.000 0.200 0.250 6095 4042 4318 510 206 17.6 30-B 4.000 1700 7000 0.750 2.000 0.200 0.250 6095 4042 4318 510 206 17.6 30-B 4.000 1700 7000 0.750 2.000 0.200 0.250 6095 5007 5317 115 50 5.55 PYRO GRAPHITE - PYRO GRAPHITE - 4130 STEEL 31-A 4.000 1700 7000 2.000 0.150 0.250 6025 6075 5075 3317 115 50 5.55 PYRO GRAPHITE - PYRO GRAPHITE - 4130 STEEL 31-B 4.000 1700 7000 2.000 0.150 0.250 6025 6095 4000 5317 1059 113 3.000 5.500 6025 6095 5007 5317 115 50 5.55 | | | | | | | | | | | | 87 | 24 | 6.73 |
| 28-C 4.000 1700 7000 0.750 2.500 0.100 0.250 5570 3426 3007 9A9 114 15.5 28-J 4.000 1700 7000 0.750 3.000 0.100 0.250 6102 4765 1624 601 190 17-7 28-K 4.000 1700 7000 0.750 3.500 0.100 0.250 6097 4765 1211 450 260 19.4 28-N 4.000 1700 7000 1.000 1.000 0.100 0.250 5970 4115 3021 60 77 14 6 28-N 4.000 1700 7000 1.000 1.000 0.100 0.250 6084 4308 3001 757 101 15.5 28-A 4.000 1700 7000 1.000 2.000 0.100 0.250 6084 4308 3001 757 101 15.5 28-A 4.000 1700 7000 1.000 2.500 0.100 0.250 6080 4363 2326 767 150 28-G 4.000 1700 7000 1.000 2.500 0.100 0.250 6080 4363 2326 767 150 28-B 4.000 1700 7000 1.000 2.500 0.100 0.250 6103 4416 1967 727 182 19.4 28-L 4.000 1700 7000 1.000 3.000 0.100 0.250 6101 4403 1537 587 200 21.5 28-M 4.000 1700 7000 1.000 3.500 0.100 0.250 6101 4403 1537 587 200 21.5 28-M 4.000 1700 7000 1.000 0.200 0.250 6101 4403 1537 587 200 21.5 28-M 4.000 1700 7000 1.000 0.200 0.250 5772 3510 2996 170 108 15.4 30-A 4.000 1700 7000 1.000 2.000 0.200 0.250 5772 3510 2996 170 108 15.4 30-A 4.000 1700 7000 1.000 2.000 0.200 0.250 6025 427 3810 322 150 15.4 30-E 4.000 1700 7000 1.000 2.000 0.200 0.250 6025 427 3810 322 150 15.4 30-B 4.000 1700 7000 0.850 2.500 0.200 0.250 6099 4504 4318 177 87 14.5 30-B 4.000 1700 7000 0.850 2.500 0.200 0.250 6099 4504 4318 177 87 14.5 30-B 4.000 1700 7000 0.850 2.500 0.200 0.250 6099 4504 4318 177 87 14.5 30-B 4.000 1700 7000 0.850 2.000 0.200 0.250 6099 4504 4318 178 87 14.5 30-B 4.000 1700 7000 0.850 2.000 0.200 0.250 6095 5607 5317 15 50 5.55 PYRO GRAPHITE - PYRO GRAPHITE - 4130 STEEL 31-A 4.000 1700 7000 0.250 1.000 0.200 0.250 6095 5607 5317 15 50 5.55 PYRO GRAPHITE - PYRO GRAPHITE - 4130 STEEL 31-A 4.000 1700 7000 2.500 0.150 0.250 6095 5607 5317 15 50 5.55 PYRO GRAPHITE - PYRO GRAPHITE - 4130 STEEL 31-A 4.000 1700 7000 2.500 0.150 0.250 6095 5607 5317 15 50 5.55 PYRO GRAPHITE - BORON CARBIDE - ASBESTOS - 4130 STEEL 31-A 4.000 1700 7000 2.500 0.150 0.250 6607 4419 343 329 38 6.65 31-B 4.000 1700 7000 2.500 0.150 0.250 6607 6409 531 342 540 540 522 540 532 540 532 540 532 | 28-D | 4.000 | 1700 | 7000 | 0.250 | 2.500 | 0.100 | 0.250 | 5363 | 4454 | 145 | 85 | | 9.63 |
| 28-S 4.000 1700 7000 0.750 3.000 0.100 0.250 6102 4765 1624 601 190 17.7 28-K 4.000 1700 7000 0.750 3.500 0.100 0.250 6007 4750 1211 450 200 17.6 28-N 4.000 1700 7000 1.000 1.000 0.100 0.250 5970 4115 3021 60 77 14 6 28-N 4.000 1700 7000 1.000 1.250 0.100 0.250 6048 4308 3001 757 101 15.3 28-A 4.000 1700 7000 1.000 2.000 0.100 0.250 6048 4308 3001 757 101 15.3 28-A 4.000 1700 7000 1.000 2.500 0.100 0.250 6080 4363 226 767 150 128-M 4.000 1700 7000 1.000 2.500 0.100 0.250 6101 4403 1537 587 200 21.5 28-M 4.000 1700 7000 1.000 3.500 0.100 0.250 6101 4403 1537 587 200 21.5 28-M 4.000 1700 7000 1.000 3.500 0.100 0.250 6101 4403 1537 587 200 21.5 28-M 4.000 1700 7000 1.000 3.500 0.100 0.250 6101 4403 1537 587 200 21.5 28-M 4.000 1700 7000 1.000 3.500 0.100 0.250 6082 4346 1075 397 200 23.3 TUMGSTEN - PYRO GRAPHITE - PYRO GRAPHITE - 4130 STEEL 30-A 4.000 1700 7000 1.000 2.000 0.200 0.250 5772 3510 2296 170 108 15.4 30-E 4.000 1700 7000 1.000 2.000 0.200 0.250 6099 4904 4318 177 87 14.5 30-B 4.000 1700 7000 0.850 2.500 0.200 0.250 6099 4904 4318 177 87 14.5 30-B 4.000 1700 7000 0.850 2.500 0.200 0.250 6099 4904 4318 510 206 17.6 30-B 4.000 1700 7000 0.750 2.000 0.200 0.250 6098 4928 4615 198 75 11.4 30-B 4.000 1700 7000 0.750 1.000 0.200 0.250 6098 4928 4615 198 75 11.4 30-B 4.000 1700 7000 0.750 1.000 0.200 0.250 6098 4928 4615 198 75 11.4 30-B 4.000 1700 7000 0.500 1.000 0.200 0.250 6095 5607 5317 115 50 5.55 PYRO GRAPHITE - PYRO GRAPHITE - 4130 STEEL 31-A 4.000 1700 7000 2.500 0.150 0.250 6095 5607 5317 115 50 5.55 31-B 4.000 1700 7000 2.500 0.150 0.250 6095 5607 5317 115 50 5.55 31-B 4.000 1700 7000 2.500 0.150 0.250 6095 5607 5317 115 50 5.55 31-B 4.000 1700 7000 2.500 0.150 0.250 6095 5607 5317 115 50 5.55 31-B 4.000 1700 7000 2.500 0.150 0.250 6095 5607 5317 115 50 5.55 31-B 4.000 1700 7000 2.500 0.150 0.250 6095 5607 5317 115 50 5.27 31-B 4.000 1700 7000 2.500 0.150 0.250 6095 5607 5317 115 50 5.27 31-B 4.000 1700 7000 2.500 0.150 0.250 6095 5607 5317 115 13 3.99 31-B 4.000 1700 7000 2.500 0.150 0.250 6 | 28-B | 4.000 | 1700 | 7000 | 0.750 | 2.000 | 0.010 | 0.250 | 5542 | 3357 | 2997 | 2626 | 88 | 14.03 |
| 28-K 4.000 1700 7000 0.750 3.500 0.100 0.250 6097 4750 1211 450 200 19.6 28-N 4.000 1700 7000 1.000 1.000 0.100 0.250 5970 4115 3021 60 77 14 6 28-H 4.000 1700 7000 1.000 1.250 0.100 0.250 6080 4308 3001 757 101 15.3 28-A 4.000 1700 7000 1.000 2.000 0.100 0.250 6080 4308 3001 757 101 15.3 28-A 4.000 1700 7000 1.000 2.500 0.100 0.250 6080 4363 2326 767 150 28-G 4.000 1700 7000 1.000 3.500 0.100 0.250 6103 4416 1967 727 182 19.4 28-L 4.000 1700 7000 1.000 3.500 0.100 0.250 6101 4403 1537 587 200 21.5 28-M 4.000 1700 7000 1.000 3.500 0.100 0.250 6101 4403 1537 587 200 21.5 28-M 4.000 1700 7000 1.000 3.500 0.100 0.250 6101 4403 1537 587 200 21.5 28-M 4.000 1700 7000 1.000 3.500 0.100 0.250 5772 3510 2996 170 108 15.6 30-A 4.000 1700 7000 1.000 2.000 0.200 0.250 5772 3510 2996 170 108 15.6 30-A 4.000 1700 7000 1.000 2.000 0.200 0.250 5772 3510 2996 170 108 15.6 30-A 4.000 1700 7000 1.000 2.000 0.200 0.250 6099 4504 4318 177 87 14.6 30-B 4.000 1700 7000 0.850 2.500 0.200 0.250 6099 4504 4318 170 200 17.6 30-B 4.000 1700 7000 0.750 2.000 0.200 0.250 5634 3644 3011 138 88 14.5 30-B 4.000 1700 7000 0.750 2.000 0.200 0.250 5634 3644 3011 138 88 14.5 30-B 4.000 1700 7000 0.750 2.000 0.200 0.250 6098 4828 4118 510 200 17.6 30-B 4.000 1700 7000 0.750 2.000 0.200 0.250 6098 4828 4118 510 200 17.6 30-B 4.000 1700 7000 0.750 2.000 0.200 0.250 6100 4730 4294 344 150 14.6 30-B 4.000 1700 7000 0.750 2.000 0.200 0.250 6101 5200 4955 97 63 8.38 30-C 4.000 1700 7000 0.500 1.000 0.200 0.250 6101 5200 4955 97 63 8.38 30-C 4.000 1700 7000 0.500 1.000 0.200 0.250 6101 5200 4955 97 63 8.38 30-C 4.000 1700 7000 0.500 1.000 0.200 0.250 6101 5200 4955 97 63 8.38 30-C 4.000 1700 7000 0.500 0.000 0.200 0.250 6101 5200 4955 97 63 8.38 30-C 4.000 1700 7000 0.500 0.000 0.200 0.250 6101 5200 4955 97 63 8.38 30-C 4.000 1700 7000 0.500 0.000 0.200 0.500 6098 4828 415 158 75 11.6 11.6 11.6 11.6 11.6 11.6 11.6 11. | | | | | | | | | | | | | _114_ | 15.20 |
| 28-H 4.000 1700 7000 1.000 1.000 0.100 0.250 5970 4115 3021 60 77 14 628-H 4.000 1700 7000 1.000 1.250 0.100 0.250 6048 4308 3001 757 101 15.3 28-A 4.000 1700 7000 1.000 2.000 0.100 0.250 6008 4363 2326 767 150 28-G 4.000 1700 7000 1.000 2.500 0.100 0.250 6103 4416 1967 727 182 19.4 28-L 4.000 1700 7000 1.000 3.000 0.100 0.250 6101 4403 1537 587 200 21.3 28-M 4.000 1700 7000 1.000 3.500 0.100 0.250 6101 4403 1537 587 200 21.3 28-M 4.000 1700 7000 1.000 3.500 0.100 0.250 6101 4403 1537 587 200 21.3 28-M 4.000 1700 7000 1.000 2.000 0.250 5772 3510 2996 170 108 15.6 30-A 4.000 1700 7000 1.000 2.000 0.200 0.250 5772 3510 2996 170 108 15.6 30-A 4.000 1700 7000 1.000 2.000 0.200 0.250 5772 3510 2996 170 108 15.6 30-A 4.000 1700 7000 1.000 1.000 0.200 0.250 6025 4227 3810 322 150 15.6 30-E 4.000 1700 7000 0.850 2.500 0.200 0.250 6099 4504 4318 177 87 14.6 30-B 4.000 1700 7000 0.850 2.500 0.200 0.250 6099 4504 4318 170 200 17.6 30-B 4.000 1700 7000 0.750 2.000 0.200 0.250 6004 3644 3011 138 88 14.6 30-E 4.000 1700 7000 0.750 2.000 0.200 0.250 6004 4304 3011 138 88 14.6 30-E 4.000 1700 7000 0.750 2.000 0.200 0.250 6004 4304 3011 138 88 14.6 30-E 4.000 1700 7000 0.750 2.000 0.200 0.250 6004 4304 3011 138 88 14.6 30-E 4.000 1700 7000 0.750 2.000 0.200 0.250 6100 4730 4254 346 150 16.3 30-E 4.000 1700 7000 0.750 2.000 0.200 0.250 6100 4730 4254 364 150 16.3 30-E 4.000 1700 7000 0.750 2.000 0.200 0.250 6108 5185 4706 353 134 10.3 30-E 4.000 1700 7000 0.250 2.000 0.250 6095 5607 5317 115 50 5.55 PYRO GRAPHITE - PYRO GRAPHITE - 4130 STEEL 31-A 4.000 1700 7000 2.000 0.150 0.250 6625 6342 1165 150 5.201 115 30 5.55 PYRO GRAPHITE - PYRO GRAPHITE - 4130 STEEL 31-B 4.000 1700 7000 2.500 0.150 0.250 6697 4493 343 28 6.601 31-92 4400 1700 7000 2.500 0.150 0.250 6697 4493 343 28 6.601 31-92 4400 1700 7000 2.500 0.150 0.250 6697 4493 343 28 1.92 | 28-J | 4.000 | 1700 | 7000 | 0.750 | 3.000 | 0.100 | 0.250 | 6102 | 4765 | 1624 | 601 | | 17.70 |
| 28-H 4.000 1700 7000 1.000 1.250 0.100 0.250 6048 4308 3001 757 101 15.3 28-A 4.000 1700 7000 1.0000 2.0000 0.100 0.250 6080 4363 2326 767 150 28-G 4.000 1700 7000 1.0000 2.500 0.100 0.250 6103 4416 1967 727 182 19.4 28-L 4.000 1700 7000 1.000 3.000 0.100 0.250 6103 4416 1967 727 182 19.4 28-H 4.000 1700 7000 1.000 3.500 0.100 0.250 6101 4403 1537 587 200 21.3 28-H 4.000 1700 7000 1.000 3.500 0.100 0.250 6103 4416 1967 397 200 23.3 TUNGSTEN - PYRO GRAPHITE - PYRO GRAPHITE - 4130 STEEL 30-A 4.000 1700 7000 1.000 2.000 0.200 0.250 5772 3510 2996 170 108 15.6 30-A 4.000 1700 7000 1.000 2.000 0.200 0.250 6025 4227 3810 322 150 15.6 30-A 4.000 1700 7000 1.000 1.000 0.200 0.250 6025 4227 3810 322 150 15.6 30-E 4.000 1700 7000 0.850 2.500 0.200 0.250 6099 4504 4318 177 87 14.6 30-B 4.000 1700 7000 0.750 2.000 0.200 0.250 6099 4504 4318 177 87 14.6 30-B 4.000 1700 7000 0.750 2.000 0.200 0.250 6099 4504 4318 170 200 17.6 30-B 4.000 1700 7000 0.750 2.000 0.200 0.250 6004 4364 3011 138 88 14.6 30-B 4.000 1700 7000 0.750 2.000 0.200 0.250 6006 428 4118 510 200 17.6 30-B 4.000 1700 7000 0.750 1.000 0.200 0.250 6006 428 4518 510 138 150 14.6 30-B 4.000 1700 7000 0.750 1.000 0.200 0.250 6006 4828 4615 198 75 11.6 30-C 4.000 1700 7000 0.750 1.000 0.200 0.250 6006 5185 6706 353 136 10.3 30-H 4.000 1700 7000 0.250 1.000 0.200 0.250 6101 5200 4955 97 63 8.3 30-H 4.000 1700 7000 0.250 1.000 0.200 0.250 6101 5200 4955 97 63 8.3 30-H 4.000 1700 7000 0.2500 0.150 0.250 6025 6402 1165 150 5.20 31-B 4.000 1700 7000 2.000 0.150 0.250 6625 6342 1165 150 5.20 31-B 4.000 1700 7000 2.000 0.150 0.250 6625 6342 1165 150 5.20 31-B 4.000 1700 7000 2.000 0.150 0.250 6625 6342 1165 150 5.20 31-B 4.000 1700 7000 2.000 0.150 0.250 6625 6342 1165 150 5.20 31-B 4.000 1700 7000 2.000 0.150 0.250 6625 6342 1165 150 5.20 31-B 4.000 1700 7000 2.000 0.150 0.250 6625 6342 1165 150 5.20 31-B 4.000 1700 7000 2.000 0.150 0.250 6625 6342 1165 130 3.9 31-D 4.000 1700 7000 0.500 0.100 0.250 6697 4493 343 28 1.92 | | | | | | | | | | | | | | <u> 19.66</u> . |
| 28-A 4.000 1700 7000 1.000 2.000 0.100 0.250 6080 4363 2326 767 150 28-G 4.000 1700 7000 1.000 2.500 0.100 0.250 6103 4416 1967 727 182 19.4 28-L 4.000 1700 7000 1.000 3.000 0.100 0.250 6101 4403 1537 587 200 21.3 28-M 4.000 1700 7000 1.000 3.500 0.100 0.250 6101 4403 1537 587 200 21.3 28-M 4.000 1700 7000 1.000 3.500 0.100 0.250 6082 4366 1075 397 200 23.3 TUNGSTEN - PYRO GRAPHITE - PYRO GRAPHITE - 4130 STEEL 30-A 4.000 1700 7000 1.000 2.000 0.200 0.250 5772 3510 2996 170 108 15.6 30-A 4.000 1700 7000 1.000 2.000 0.200 0.250 6025 4227 3810 322 150 12.6 30-E 4.000 1700 7000 1.000 1.000 0.200 0.250 6099 4504 4918 177 87 14.1 30-J 4.000 1700 7000 0.850 2.500 0.200 0.250 6099 4504 4918 177 87 14.1 30-B 4.000 1700 7000 0.750 2.000 0.200 0.250 6099 4504 3011 138 88 14.6 30-B 4.000 1700 7000 0.750 2.000 0.200 0.250 6098 4828 4615 138 75 11.4 30-F 4.000 1700 7000 0.500 1.000 0.200 0.250 6098 4828 4615 138 75 11.4 30-F 4.000 1700 7000 0.500 1.000 0.200 0.250 6098 4828 4615 138 75 11.4 30-B 4.000 1700 7000 0.500 1.000 0.200 0.250 6108 5185 4706 351 134 10.3 30-B 4.000 1700 7000 0.250 2.000 0.200 0.250 6108 5200 4955 97 63 8.38 30-B 4.000 1700 7000 0.250 2.000 0.200 0.250 6108 5200 4955 97 63 8.38 30-B 4.000 1700 7000 0.250 2.000 0.250 6108 5418 5078 311 115 8.00 31-B 4.000 1700 7000 0.250 0.150 0.250 6625 6342 1165 150 5.25 PYRO GRAPHITE - PYRO GRAPHITE - 4130 STEEL 31-A 4.000 1700 7000 2.500 0.150 0.250 6625 6342 1165 150 5.25 31-B 4.000 1700 7000 2.500 0.150 0.250 6625 6342 1165 150 5.25 31-B 4.000 1700 7000 2.500 0.150 0.250 6625 6342 1165 150 5.25 31-B 4.000 1700 7000 2.500 0.150 0.250 6697 4493 343 28 1.92 PYRO GRAPHITE - BORON CARBIDE - ASBESTOS - 4130 STEEL 32-A 4.000 1700 7000 1.500 0.100 0.250 6697 4493 343 28 1.92 | 28-H | 4.000 | 1700 | 7000 | 1 - 000 | 1 - 250 | 0-100 | 0.250 | 5910 | 4112 | 3021 | 90 787 | | |
| 28-G 4.000 1700 7000 1.000 2.500 0.100 0.250 6103 4416 1967 727 182 19.4 28-L 4.000 1700 7000 1.000 3.000 0.100 0.250 6101 4403 1537 587 200 21.3 28-M 4.000 1700 7000 1.000 3.500 0.100 0.250 6101 4403 1537 587 200 21.3 28-M 4.000 1700 7000 1.000 3.500 0.100 0.250 6082 4346 1075 397 200 23.3 TUNGSTEN - PYRO GRAPHITE - PYRO GRAPHITE - 4130 STEEL 30-A 4.000 1700 7000 1.000 2.000 0.200 0.250 5772 3510 2996 170 108 15.4 30-E 4.000 1700 7000 1.000 1.000 0.200 0.250 6095 4227 3810 322 150 15.4 30-B 4.000 1700 7000 0.850 2.500 0.200 0.250 6099 4504 4318 177 87 14.5 30-B 4.000 1700 7000 0.850 2.500 0.200 0.250 6099 4504 4318 177 87 14.5 30-B 4.000 1700 7000 0.750 2.000 0.200 0.250 6099 428 4118 310 200 17.5 30-F 4.000 1700 7000 0.750 2.000 0.200 0.250 6098 4828 4611 198 88 14.1 30-B 4.000 1700 7000 0.750 2.000 0.200 0.250 6098 4828 4615 198 75 11.4 30-C 4.000 1700 7000 0.500 1.000 0.200 0.250 6098 4828 4615 198 75 11.4 30-C 4.000 1700 7000 0.500 1.000 0.200 0.250 6098 4828 4615 198 75 11.4 30-B 4.000 1700 7000 0.500 1.000 0.200 0.250 6101 5200 4955 97 63 8.38 30-D 4.000 1700 7000 0.250 2.000 0.250 6105 5418 5078 311 115 8.00 30-H 4.000 1700 7000 0.250 2.000 0.250 6095 5607 5317 115 50 5.55 PYRO GRAPHITE - PYRO GRAPHITE - 4130 STEEL 31-A 4.000 1700 7000 2.500 0.150 0.250 6625 6422 1165 150 5.27 31-B 4.000 1700 7000 2.500 0.150 0.250 6625 6422 1165 150 5.27 31-B 4.000 1700 7000 2.500 0.150 0.250 5625 6425 1369 130 5.27 31-B 4.000 1700 7000 2.500 0.150 0.250 5607 5317 115 50 5.27 31-B 4.000 1700 7000 2.500 0.150 0.250 6625 6422 1165 150 5.27 31-B 4.000 1700 7000 2.500 0.150 0.250 6625 6422 1165 130 5.27 31-B 4.000 1700 7000 2.500 0.150 0.250 6625 6422 1165 130 5.27 31-B 4.000 1700 7000 2.500 0.150 0.250 6625 6422 1165 130 5.27 31-B 4.000 1700 7000 2.500 0.150 0.250 6625 6422 1165 130 5.27 31-B 4.000 1700 7000 2.500 0.150 0.250 6625 6425 165 322 88 663 31-C 4.000 1700 7000 2.500 0.150 0.250 6697 4493 343 28 1.92 | 28-A | 4.000 | 1700 | 7000 | 1.000 | 2.000 | 0.100 | 0.250 | 4080 | 4343 | 2324 | 747 | | |
| 28-L 4.000 1700 7000 1.000 3.000 0.100 0.250 6101 4403 1537 587 200 21.3 28-M 4.000 1700 7000 1.000 3.500 0.100 0.250 6082 4346 1075 397 200 23.3 TUNGSTEN - PYRO GRAPHITE - PYRO GRAPHITE - 4130 STEEL 30-A 4.000 1700 7000 1.000 2.000 0.200 0.250 5772 3510 2996 170 108 15.6 30-A 4.000 1700 7000 1.000 2.000 0.200 0.250 6025 4227 3810 322 150 15.6 30-E 4.000 1700 7000 0.850 2.500 0.200 0.250 6099 4504 4318 177 87 14.6 30-B 4.000 1700 7000 0.850 2.500 0.200 0.250 6099 4504 4318 177 87 14.6 30-B 4.000 1700 7000 0.750 2.500 0.200 0.250 6099 4628 4118 510 200 17.6 30-E 4.000 1700 7000 0.750 2.000 0.200 0.250 6099 4628 4118 510 200 17.6 30-E 4.000 1700 7000 0.750 2.000 0.200 0.250 6098 428 4615 198 75 11.6 30-E 4.000 1700 7000 0.750 1.000 0.200 0.250 6098 428 4615 198 75 11.6 30-E 4.000 1700 7000 0.500 1.000 0.200 0.250 6098 428 4615 198 75 11.6 30-E 4.000 1700 7000 0.500 1.000 0.200 0.250 6010 4790 4254 366 150 14.5 30-E 4.000 1700 7000 0.500 1.000 0.200 0.250 6010 500 4955 97 63 8.31 30-E 4.000 1700 7000 0.500 1.000 0.200 0.250 6101 5200 4955 97 63 8.31 30-E 4.000 1700 7000 0.500 1.000 0.200 0.250 6095 5607 5317 115 50 5.50 PYRO GRAPHITE - PYRO GRAPHITE - 4130 STEEL 31-A 4.000 1700 7000 2.500 0.150 0.250 6095 5607 5317 115 50 5.27 31-B 4.000 1700 7000 2.500 0.150 0.250 6625 6422 1165 130 5.27 31-B 4.000 1700 7000 2.500 0.150 0.250 6625 6422 1165 130 5.27 31-B 4.000 1700 7000 2.500 0.150 0.250 6625 6422 1165 130 5.27 31-B 4.000 1700 7000 2.500 0.150 0.250 6625 6422 1165 130 5.27 31-B 4.000 1700 7000 2.500 0.150 0.250 6625 6422 1165 130 5.27 31-B 4.000 1700 7000 2.500 0.150 0.250 6625 6422 1165 130 5.27 31-B 4.000 1700 7000 2.500 0.150 0.250 6625 6422 1165 130 5.27 31-B 4.000 1700 7000 2.500 0.150 0.250 6625 6422 1165 130 5.27 31-B 4.000 1700 7000 2.500 0.150 0.250 6625 6422 1165 130 5.27 31-B 4.000 1700 7000 2.500 0.150 0.250 6625 6422 1165 130 5.27 31-B 4.000 1700 7000 2.500 0.150 0.250 6625 6422 1165 130 5.27 31-B 4.000 1700 7000 2.500 0.150 0.250 6625 6422 1165 130 5.27 | 28-G | 4.000 | 1700 | 7000 | 1.000 | 2.500 | 0.100 | 0.250 | 6103 | 4416 | 1967 | 727 | | 19.43 |
| TUNGSTEN | | | | | | | | | | | | | | 21.30 |
| 30-A 4.000 1700 7000 1.000 2.000 0.200 0.250 5772 3510 2996 170 108 15.6 30-A 4.000 1700 7000 1.000 2.000 0.200 0.250 6025 4227 3810 322 150 15.6 30-E 4.000 1700 7000 1.000 1.000 0.200 0.250 6099 4504 4318 177 87 14.7 30-J 4.000 1700 7000 0.850 2.500 0.200 0.250 6099 4504 4318 177 87 14.7 30-J 4.000 1700 7000 0.850 2.500 0.200 0.250 6099 4628 4118 510 206 17.6 30-B 4.000 1700 7000 0.750 2.000 0.200 0.250 5634 3644 3011 138 88 14.3 30-B 4.000 1700 7000 0.750 2.000 0.200 0.250 6100 4730 4294 346 150 14.3 30-F 4.000 1700 7000 0.750 1.000 0.200 0.250 6098 4828 4615 198 75 11.4 30-C 4.000 1700 7000 0.500 1.000 0.200 0.250 6098 4828 4615 198 75 11.4 30-C 4.000 1700 7000 0.500 1.000 0.200 0.250 6101 5200 4955 97 63 8.38 30-B 4.000 1700 7000 0.500 1.000 0.200 0.250 6101 5200 4955 97 63 8.38 30-B 4.000 1700 7000 0.250 2.000 0.200 0.250 6101 5200 4955 97 63 8.38 30-B 4.000 1700 7000 0.250 2.000 0.200 0.250 6101 5200 4955 97 63 8.38 30-B 4.000 1700 7000 0.250 2.000 0.200 0.250 6101 5200 4955 97 63 8.38 30-B 4.000 1700 7000 0.250 2.000 0.250 6095 5607 5317 115 50 5.55 9700 0.250 0.250 0.250 6095 5607 5317 115 50 5.27 31-A 4.000 1700 7000 2.000 0.150 0.250 6625 6342 1165 150 5.27 31-A 4.000 1700 7000 2.500 0.150 0.250 6625 6342 1165 150 5.27 31-A 4.000 1700 7000 2.500 0.150 0.250 6625 6342 1165 150 5.27 31-A 4.000 1700 7000 2.500 0.150 0.250 6625 6342 1165 150 5.27 31-A 4.000 1700 7000 2.500 0.150 0.250 6625 6342 1165 150 5.27 31-A 4.000 1700 7000 2.500 0.150 0.250 6625 6342 1165 150 5.27 31-A 4.000 1700 7000 2.500 0.150 0.250 6625 6342 1165 150 5.27 31-A 4.000 1700 7000 2.500 0.150 0.250 6625 6342 1165 150 5.27 31-A 4.000 1700 7000 2.500 0.150 0.250 6625 6342 1165 129 13 3.94 6625 6342 1165 150 6625 6342 1165 150 6625 6342 1165 150 6625 6342 1165 150 6625 6342 1165 150 6625 6342 1165 150 6625 6342 1165 150 6625 6342 1165 150 6625 6342 1165 150 6625 6342 1165 150 6625 6342 1165 150 6625 6342 1165 150 6625 6342 1165 150 6625 6342 1165 150 6625 6342 1165 150 6625 6342 1165 150 6625 6342 1165 150 6625 6342 1165 150 6625 6342 1 | | | | | | | | | | | | | 200 | 23.32 |
| 30-A 4.000 1700 7000 1.000 2.000 0.200 0.250 5772 3510 2996 170 108 15.6 30-A 4.000 1700 7000 1.000 2.000 0.200 0.250 6025 4227 3810 322 150 15.6 30-E 4.000 1700 7000 1.000 1.000 0.200 0.250 6099 4504 4318 177 87 14.7 30-J 4.000 1700 7000 0.850 2.500 0.200 0.250 6099 4504 4318 177 87 14.7 30-J 4.000 1700 7000 0.850 2.500 0.200 0.250 6099 4628 4118 510 206 17.6 30-B 4.000 1700 7000 0.750 2.000 0.200 0.250 6100 4730 4294 346 150 138 88 14.3 30-B 4.000 1700 7000 0.750 2.000 0.200 0.250 6100 4730 4294 346 150 14.3 30-F 4.000 1700 7000 0.750 1.000 0.200 0.250 6098 4828 4615 198 75 11.4 30-C 4.000 1700 7000 0.500 1.000 0.200 0.250 6098 4828 4615 198 75 11.4 30-C 4.000 1700 7000 0.500 1.000 0.200 0.250 6101 5200 4955 97 63 8.38 30-B 4.000 1700 7000 0.500 1.000 0.200 0.250 6101 5200 4955 97 63 8.38 30-B 4.000 1700 7000 0.250 2.000 0.200 0.250 6101 5200 4955 97 63 8.38 30-B 4.000 1700 7000 0.250 1.000 0.200 0.250 6101 5200 4955 97 63 8.38 30-B 4.000 1700 7000 0.250 2.000 0.200 0.250 6101 5200 4955 97 63 8.38 30-B 4.000 1700 7000 0.250 1.000 0.200 0.250 6095 5607 5317 115 50 5.55 31-A 4.000 1700 7000 2.500 0.150 0.250 6625 6342 1165 150 5.27 31-A 4.000 1700 7000 2.500 0.150 0.250 6625 6342 1165 150 5.27 31-B 4.000 1700 7000 2.500 0.150 0.250 5582 4415 329 88 6.65 31-B 4.000 1700 7000 2.500 0.150 0.250 5582 4415 329 88 6.65 31-B 4.000 1700 7000 2.500 0.150 0.250 5582 4415 329 88 6.65 31-B 4.000 1700 7000 2.500 0.150 0.250 6697 4493 343 28 1.92 81 6.65 31-B 4.000 1700 7000 2.500 0.150 0.250 6697 4493 343 28 1.92 81 6.65 31-B 4.000 1700 7000 2.500 0.150 0.250 6697 4493 343 28 1.92 82-A 4.000 1700 7000 1.000 1.000 0.250 5300 4406 2827 382 54 5.30 82-A 4.000 1700 7000 1.000 1.000 0.250 5300 4406 2827 382 54 5.30 82-A 4.000 1700 7000 1.000 1.000 0.250 5300 4406 2827 382 54 5.30 82-A 4.000 1700 7000 1.000 1.000 0.250 5300 4406 2827 382 54 5.30 82-A 4.000 1700 7000 1.000 1.000 0.250 5300 4406 2827 382 54 5.30 82-A 4.000 1700 7000 1.000 1.000 0.250 5300 4406 2827 382 54 5.30 82-A 4.000 1700 7000 1.000 1.000 0.250 5300 4406 2827 3 | TIME | PTEN | 841 | | | - | 400 60 | | | | | | | • |
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| 30-B 4.000 1700 7000 0.850 2.500 0.200 0.250 6099 4628 4118 510 206 17.6 30-B 4.000 1700 7000 0.750 2.000 0.200 0.250 5634 3644 3011 138 88 14.1 30-B 4.000 1700 7000 0.750 2.000 0.200 0.250 6100 4730 4254 344 150 14.1 30-F 4.000 1700 7000 0.750 1.000 0.200 0.250 6098 4828 4615 158 75 11.4 30-C 4.000 1700 7000 0.500 2.000 0.200 0.250 6098 4828 4615 158 75 11.4 30-G 4.000 1700 7000 0.500 1.000 0.200 0.250 6106 5185 4704 353 134 10.5 30-B 4.000 1700 7000 0.500 1.000 0.200 0.250 6101 5200 4955 97 63 8.38 30-D 4.000 1700 7000 0.250 2.000 0.200 0.250 6108 5618 5075 311 115 8.05 30-H 4.000 1700 7000 0.250 1.000 0.200 0.250 6095 5607 5317 115 50 5.55 PYRO GRAPHITE - PYRO GRAPHITE - 4130 STEEL 31-A 4.000 1700 7000 2.000 0.150 0.250 4419 2687 90 31 5.27 31-B 4.000 1700 7000 2.500 0.150 0.250 6625 6342 1165 150 5.27 31-B 4.000 1700 7000 2.500 0.150 0.250 6625 6342 1165 150 5.27 31-B 4.000 1700 7000 2.500 0.150 0.250 6625 6342 1165 150 5.27 31-B 4.000 1700 7000 2.500 0.150 0.250 6700 6420 1951 236 6.61 31-C 4.000 1700 7000 2.500 0.150 0.250 6704 6517 1689 113 3.94 PYRO GRAPHITE - BORON CARBIDE - ASBESTOS - 4130 STEEL 32-A 4.000 1700 7000 1.000 1.000 0.250 5304 4406 2827 382 54 5.36 | | | | | | | | | | | | | | 14.76 |
| 30-B 4.000 1700 7000 0.750 2.000 0.200 0.250 5634 3644 3011 138 88 14.1 30-B 4.000 1700 7000 0.750 2.000 0.200 0.250 6100 4730 4254 346 150 14.1 30-F 4.000 1700 7000 0.750 1.000 0.200 0.250 6098 4828 4615 158 75 11.4 30-C 4.000 1700 7000 0.500 2.000 0.200 0.250 6106 5185 4704 353 134 10.5 30-G 4.000 1700 7000 0.500 1.000 0.200 0.250 6101 5200 4955 97 63 8.38 30-D 4.000 1700 7000 0.250 2.000 0.200 0.250 6101 5200 4955 97 63 8.38 30-H 4.000 1700 7000 0.250 1.000 0.200 0.250 6108 5418 5075 311 115 8.05 30-H 4.000 1700 7000 0.250 1.000 0.200 0.250 6095 5607 5317 115 50 5.55 PYRO GRAPHITE - PYRO GRAPHITE - 4130 STEEL 31-A 4.000 1700 7000 2.000 0.150 0.250 4419 2687 90 31 5.27 31-B 4.000 1700 7000 2.000 0.150 0.250 6625 6342 1165 150 5.27 31-B 4.000 1700 7000 2.500 0.150 0.250 6625 6342 1165 150 5.27 31-B 4.000 1700 7000 2.500 0.150 0.250 6700 6420 1951 236 6.61 31-C 4.000 1700 7000 1.500 0.100 0.250 6704 6517 1689 113 3.94 31-D 4.000 1700 7000 0.500 0.100 0.250 6697 4493 343 28 1.92 PYRO GRAPHITE - BORON CARBIDE - ASBESTOS - 4130 STEEL 32-A 4.000 1700 7000 1.000 1.000 0.100 0.250 5304 4406 2827 382 54 5.36 | | | | | | | | | | | | | | 17.07 |
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| 30-H 4.000 1700 7000 0.250 1.000 0.200 0.250 6095 5607 5317 115 50 5.55 PYRO GRAPHITE - PYRO GRAPHITE - 4130 STEEL 31-A 4.000 1700 7000 2.000 0.150 0.250 4419 2687 90 31 5.27 31-B 4.000 1700 7000 2.000 0.150 0.250 6625 6342 1165 150 5.27 31-B 4.000 1700 7000 2.500 0.150 0.250 5582 4415 329 88 6.61 31-B 4.000 1700 7000 2.500 0.150 0.250 6700 6420 1951 236 6.61 31-C 4.000 1700 7000 1.500 0.100 0.250 6704 6517 1669 113 3.94 31-D 4.000 1700 7000 0.500 0.100 0.250 6697 4493 343 28 1.92 PYRO GRAPHITE - BORON CARBIDE - ASBESTOS - 4130 STEEL 32-A 4.000 1700 7000 1.000 1.000 0.100 0.250 5304 4406 2827 382 54 5.36 | | | | | | | | | | | | | | |
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| 31-C 4-000 1700 7000 1-500 0-100 0-250 6704 6517 1689 113 3-94 31-D 4-000 1700 7000 0-500 0-100 0-250 6697 4493 343 28 1-92 PYRO GRAPHITE - BORON CARBIDE - ASBESTOS - 4130 STEEL 32-A 4-000 1700 7000 1-000 1-000 0-100 0-250 5304 4406 2827 382 54 5-36 | 31- • | 4.000 | 1700 | 7000 | <u> 2.500</u> | 0.150 | 0.250 | | | | | | | |
| 31-D 4-000 1700 7000 0-500 0-100 0-250 6697 4493 343 28 1-92 PYRO GRAPHITE - BORON CARBIDE - ASBESTOS - 4130 STEEL 32-A 4-000 1700 7000 1-000 1-000 0-100 0-250 5304 4406 2827 382 54 5-36 | | | | | | | | | | | | | | 6.61 |
| PYNO GRAPHITE - BORON CARBIDE - ASBESTOS - 4130 STEEL 32-A 4-000 1700 7000 1-000 1-000 0-100 0-250 5304 4406 2827 382 54 5-36 | | | | | | | | | | | | | | |
| 32-A 4-000 1700 7000 1-000 1-000 0-100 0-250 5304 4406 2827 382 54 5-30 | | | | | | | | | 0 0 7/ | | J43 | | | 1.76 |
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| 25-8 40000 1000 1000 10000 50000 00100 00530 2508 4301 AA3 104 94 8033 | 35-¥ | 4.000 | 1700 | 7000 | 1.000 | 1.000 | 0-100 | 0.250 | 2304 | 4406 | 2827 | 382 | - 54 | <u> 5.30</u> |
| | 32-6 | 4.000 | 1 100 | 1000 | 1.000 | 2.000 | 0.100 | 0.250 | 7205 | 4301 | 773 | 164 | •• | 4.33 |

| TUNG | STEN-P | YRO GI | RAPHI | TE-ASE | ESTOS | -4130 | STEE | L | | •••• | | | | |
|-----------------|----------------|----------------|-------|--------|--------------|--------|-------------|-------------|-------------|---|-------------|------|-------------------|----------------------|
| 13-8 | 4.000 | 1700 | 7000 | 1.000 | 1.00 | 0 0 10 | 10_0. | 250 | 5452 | 1272 | 3004 | .259 | _ 30 , | 13,26 . |
| 33-0 | 4.000 | 1700 | 7000 | 1.000 | 1.50 | 0.0.10 | 0.0 | 250 | 5721 | 3397 | 2995 | 452 | _7 A | 15.74 |
| 33-D | 4.000 | 1700 | 7000 | 1.000 | 2.00 | 0 0.10 | 0 0. | 250 | 5776 | 3518 | 2997 | 871 | 109 | 17.23 |
| | 4.000 | <u> 1700</u> . | 7000 | 1.000 | 2.50 | 0.0.10 | 10.0. | 250 | 3821 | 3427 | 3001 | 1094 | 145_ | _18.81 |
| 33-F | 4.000 | 1700 | 7000 | 1.000 | 3.00 | 0.10 | 0 0. | 250 | 5860 | 3724 | 3006 | 1311 | | 20.15 |
| 33-H | 4.000 | 1700 | 7000 | 0.500 | 1.00 | U Dale | 10 Da | 250 | 4227 | 3467 | 3028 | 340 | <u> 15</u> 29 | 7 <u>004</u> 8•11 |
| 33-1 | 4.000 | 1700 | 7000 | 0.500 | 1.50 | 0 0.10 | | 250 | 5343 | 3455 | 3004 | 412 | <u> </u> | |
| 33-K | 4.000 | 1700 | 7000 | 0.500 | 2.00 | 0 0.10 | 0 0. | 250 | 5434 | 3821 | 3005 | 586 | 69 | 10.63 |
| 33-1 | 4.000 | 1700 | 7000 | 0.500 | 2.50 | 0_0_10 | 0.0 | 250 | 5507 | 3960 | 3002 | 772 | 95 | _12.08 |
| 33-M | 4.000 | 1700 | 7000 | 0.500 | 3.00 | 0.10 | 0 0. | 250 | 5567 | 4077 | 2996 | 964 | 125 | 13.66 |
| CASE | DIA | MAT-1 | MAT | -2 MAT | -3 MA | T-4 MA | T-5 | T1 | T2 | T3 | 74 | TS | DUR | WT |
| TUNG: | STEN-A | TJ GRA | PHIT | E-BORC | N CAR | BIDE- | SBES | TOS | -4130 | STEE | L (HT | =170 | 0 • TG= | 7000) |
| 34-0 | 4.000 4.000 | 0.500 | 1.0 | 00 1.0 | DO O | 100 0 | 250 | 610 | 514 | 2_3 67 (| 2020 | | 112 | |
| 34-B | 4.000 | 0.250 | 1.00 | 00 1.0 | 05 04 | 100 0 | 250 | 608 | 557 | 2 387 | 299 | 744 | _98 | |
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Aerojet-General Corp. In ASTIA collection Contract No. AF 33 properties effects Analyses and test AFSC Project 7350 E. M. Sadownick Avel. fr. OTS: progress Material rozzle Thermophysical (616)-7365 Task 73500 Duretion ayatems II. 4 H Patterson Air Force Base, Ohio. Rpt. No. WADC-TR-59-602 Pt. II. INVESTIGATION OF MAT-ERIALS CAPABILITIES OF MATERIAL SYSTEMS IN HEAT TRANSFER FACTORS. Interim Rpt. February 1962, 94p incl. illus., tebles. (2) the proximity of actual to calculated temperature distributions, and (3) the effect of aluminum oxide deposition on materials Temperature histories of various nozzle mat-rials systems were analyzed parametrically, and a series of hot-flow tests were conduct-ed in support of the analytical study. Re-sults of the analyses showed the interrelat-lonship of material combinations in relation (over) showed (1) effects of flame barrier and insulation thickness on duration capability, Unclassified report to duration. Results of the test program SOLID HOCKET MOTORS Part II. ANALYSIS OF Aeronautical Systems Division, Wrightsystem capebility Aerojet-Ceneral Corp. In ASTIA collection Task 73500 Contract No. AF 33 properties effects Duretion AFSC Project 7350 Analyses and test E. M. Sadownick Avel. fr. OTS: Materiel rozzle Thermophysical (616)-7365 program systems ï. m તં ÷∺ Patterson Air Force Base, Onio. Fpt. No. walk-TR-59-602 Pt. II. INVESTIGATION OF MATERIES CAPABILITIES OF MATERIAL SYSTEMS IN SOLID FOCKET NOTORS Pert II. ANALYSIS OF HEAT TRANSER FACTORS. Interin Rpt. February 1962, 94p incl. illus., tables. showed (1) effects of flame barrier and insulation thickness on duration capability. (2) the proximity of actual to calculated temperature distributions, and (3) the effect of aluminum oxide deposition on materials erials systems were analyzed parametrically, and a series of hot-flow tests were conducted in support of the analytical study. Results of the analyses showed the interrelationship of material combinations in relation (over) Temperature histories of various nozzle mat-Unclassified report to duration. Results of the test program Aeronautical Systems Division, Wrightsystem capsbility 1.

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